Field

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A QUARTERLY DEVOTED TO MEDICAL ZOOLOGY

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Volume I

ANNOUNCEMENT

The advisability of establishing an American publication in the field of parasitology has been under discussion for some time. Such a journal is clearly demanded by the increasing amount of work in this field, the growing importance of the subject in its broader aspects as related to disease in man and other animals and the intense biological interest in associated theoretical problems, together with the evident advantages of a representative publication and the lack of adequate opportunity for printing such papers elsewhere.

The Journal of Parasitology will be a medium for the prompt publication of briefer papers and research notes on animal parasites. Emphasis will be laid on the morphology, life history and biology of zooparasites, and the relations of animals to disease. Under present conditions it will not be practicable to print monographic articles, and ordinarily individual papers will be limited to ten or fifteen text pages.

The Journal will publish the reports of the Helminthological Society of Washington and a brief record of personal and institutional items in parasitology. Individual papers will not usually be reviewed, but books or monographs of noteworthy character and technical methods of marked value will be given appropriate notice. An effort will be made to eliminate the casual notice or abstract; critical summaries by those who are entitled to pass judgment in the special field are welcomed and some such are already pledged.

The final policy of The Journal will be developed in the light of experience to the end that it may contribute as effectively as possible to the dissemination of knowledge and the encouragement of teaching and research in parasitology.

A guarantee fund subscribed by various individuals and institutions assures the regular appearance of this periodical quarterly at least for a three-year period, so that the Editorial Board will devote its attention to determining broadly the needs of the field and the best methods of serving them.

A series of distinguished foreign workers have consented to become collaborators in the work of The Journal, and contributions to its pages from some of them have already been received. Owing to present confusion in the mail service this list is not perfect and will appear later.

The expressions of interest and encouragement that have come unsolicited on the appearance of the preliminary announcement indicate clearly the favorable reception awaiting the appearance of the new publication. It will depend for its success on the continuance of this attitude, and to that end welcomes all suggestions as to the methods by which it may best serve the field of science to which it is devoted. It hopes to deserve the approval and continued support of the professional world.

THE EDITORIAL BOARD

The Journal of Parasitology

Volume 1 SEPTEMBER, 1914 Number 1

THE DESTRUCTION OF THE VITALITY OF CYSTICERCUS BOVIS BY FREEZING

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The question as to the length of time *Cysticercus bovis* may survive after the death of its host has been quite definitely settled by the researches of Perroncito, Zschocke, Ostertag and others. Perroncito (1877) found that the cysticerci in an artificially infested calf were all dead fourteen days after the slaughter of the animal. However, Zschocke (1896) succeeded in infesting the human subject with a tapeworm by feeding five cysticerci from beef kept from fourteen to sixteen days after slaughter. No infestation followed the swallowing of five cysticerci from beef kept twenty-one days after slaughter. Ostertag (1897) examined in a thermostat a large number of cysticerci from beef kept in cold storage at temperatures above freezing for various periods of time after slaughter and concluded that the parasites are no longer capable of development on the twentieth day, although slight movements were observed in a few cysticerci as late as twenty-four days after slaughter. These results were confirmed by feeding experiments in which thirty-four persons swallowed cysticerci from beef held in cold storage at temperatures above freezing for from twenty to twenty-one days after slaughter. No tapeworm infestation resulted in any case.

The conclusions from these investigations are that a lapse of twenty-one days after slaughter is amply sufficient to insure the death of the beef cysticercus, and on the other hand that fourteen days is not sufficient, although in some cases, as determined by Perroncito in one instance, the parasites may have lost their vitality within this shorter period of time. Cognizance has been taken of these results in the meat-inspection regulations of Germany, United States and other countries, which provide that beef carcasses showing infestation with cysticerci in a certain slight degree may be passed for food after retention in cold storage for twenty-one days.

The question of the period of time *Cysticercus bovis* may survive after the death of its host having been settled, the next question which arises is whether this period may be shortened by artificial means. The means which naturally suggests itself as the least objectionable in its effects on meat and the most practicable of application is exposure to low temperatures. Reissmann (1897) has reported that beef cysticerci inserted into the depths of large pieces of meat which were then kept at temperatures of from — 8 to — 10 C. (17.6 to 14 F.) do not survive when thus exposed for three days. *Cysticercus cellulosae* appeared to be somewhat more resistant and required four days exposure before its vitality was destroyed. Prior to Reissmann, Glage (1896) noted that in the case of a measly pork ham (11 kg. in weight) which was exposed to a low temperature and solidly frozen, most of the cysticerci were still alive after two days of such exposure. As a result of several experiments Boccalari (1903) concluded that *Cysticercus bovis* and *C. cellulosae* die in four days at a temperature of from — 4 to — 6 C. (24.8 to 21.2 F.) and in six days at a temperature of from 0 to — 2 C. (32 to 28.4 F.).

Recent experiments by the writer on *Cysticercus bovis* have led to somewhat different results than those obtained by Reissmann and Boccalari, and in fact have shown that the exposure of measly beef to temperatures as low as 15 F. for four days is not sufficient to insure a complete destruction of the vitality of the cysticerci. In these experiments two beef carcasses, heavily infested with live cysticerci, were used. The carcasses were allowed to hang for about twenty-four hours after slaughter in a chill-room, the temperature of which was somewhat higher than the freezing-point. They were then quartered and placed in a cold-storage compartment (freezer), in which the temperature varied during the experiments between 11 and 15 F.; most of the time between 14 and 15. The temperature of the freezer was taken at four-hour intervals. The thermometer used was checked with a thermometer recently standardized by the Bureau of Standards. In the case of one of the carcasses, a quarter was retained in the chill-room, in order that check observations might be made on unfrozen cysticerci. Examination of one of the quarters of beef was made two days after it had been placed in the freezer, at which time it was found that the deeper portions of the meat had not yet become solidly frozen. All of the beef kept in the freezer longer than two days was found to be solidly frozen throughout.

Portions of one of the carcasses were removed from the freezer after a lapse of two, three and six days, respectively, allowed to thaw, and eighteen to twenty-four hours after removal dissected. The cysticerci were isolated, removed from their cysts and examined on a

warm stage kept at a temperature of 40 to 45 C. Careful observations were made to detect signs of life. If the parasite did not move and showed no response to stimulation with a needle-point it was considered dead. The heads of those cysticerci which showed no movement in the retracted condition were evaginated by pressure and carefully observed, as it was found that in such cases the head and neck sometimes still showed feeble movements, not perceptible in the retracted cysticercus.

Lack of opportunity prevented a prompt and careful examination of thirty-six cysticerci removed from the beef kept two days in the freezer, but it was observed that one of them showed definite signs of life. These cysticerci were taken from the superficial frozen portions of the meat.

Sixteen cysticerci from the beef kept three days in the freezer were examined and seven, or 44 per cent., were found to be alive.

Sixty-three cysticerci from the beef kept six days in the freezer were examined and none was found alive. Six others were removed from the same meat with special precautions to prevent possible injury. The cysts were left intact, together with a small amount of surrounding muscular tissue. These six cysticerci were swallowed by a human subject (the writer). Eighteen weeks (Sept. 23, 1913, to Jan. 29, 1914) have elapsed and no signs of tapeworm infestation have yet appeared.

Meat from the other carcass was removed from the freezer after a lapse of four, five and six days, respectively, and allowed to thaw, after which the cysticerci were isolated and examined as in the case of the first carcass.

Forty per cent. of the cysticerci from the beef kept four days in the freezer proved to be alive; that is, ten out of twenty-five examined.

Only one out of twenty-one cysticerci, or 5 per cent., was still alive in the beef kept in the freezer for five days, and this one showed such faint signs of life that it probably would have been incapable of development in the human host.

Thirty cysticerci were examined from the beef kept six days in the freezer and none showed any evidence of being alive. Five others, intact in their cysts and surrounded by small portions of muscular tissue, were swallowed by a human subject (the writer). An examination was made of twelve cysticerci from the portion of the same carcass, which had been kept since slaughter, eight days in all in an unfrozen condition, and all were found to be alive and active. Fifteen weeks (Oct. 16, 1913, to Jan. 29, 1914) have elapsed since the five cysticerci above referred to were swallowed and no evidence of tapeworm infestation has yet appeared.

From these experiments it may be concluded that if measly beef carcasses are exposed for six days to a temperature not exceeding 15 F. (— 9.44 C.) the vitality of the cysticerci will be destroyed, that some may survive in carcasses exposed for five days to this temperature, though it is doubtful whether they will retain sufficient vitality to develop in the human host, and finally that a considerable proportion may survive in carcasses exposed to a temperature of 15 F. for four days or less. Though it is possible that the vitality of the cysticerci, which were observed to be alive after exposure of the infested beef to a temperature of 15 F. for four days, had been so seriously affected that they would have been incapable of producing tapeworm infestation, the fact that they were alive and active justifies the adoption of a longer period of retention when refrigeration is employed as a sanitary measure. Likewise it would seem, notwithstanding the evidently weakened condition of the only cysticercus which survived in beef exposed five days to a temperature of 15 F., that it is not justifiable to accept five days as a safe period for refrigeration, and that six days should be required until it shall be shown that a shorter period of refrigeration is fully sufficient to prevent the possibility that cysticerci present in the refrigerated meat may retain enough vitality to continue their development in the human host. On the basis of the results which have been herein recorded, an amendment to the federal meat inspection regulations has been issued providing that beef carcasses showing a certain slight degree of infestation may be passed for food if held for six days at a temperature not exceeding 15 F., as an alternative to the requirement of retention for twenty-one days. As over 40,000 beef carcasses are annually retained on account of *Cysticercus bovis* in establishments under federal inspection, this modification of the regulations will result in a considerable saving in the handling of such carcasses. Some carcasses, particularly heavy carcasses of the highest quality of beef, suffer little or no deterioration when held for twenty-one days in coolers at temperatures above freezing, and these are likely to be held in coolers as heretofore for the full twenty-one-day period. Many of the carcasses, however, which are retained on account of *Cysticercus bovis,* are of such a character that they cannot be kept unspoiled for three weeks unless they are frozen. Under the new regulations, instead of being refrigerated for three weeks, these carcasses will be held for six days at a temperature not higher than 15 F. and then released for food. The refrigeration expense will thus be greatly reduced. Only about a third as much cold will have to be produced for each carcass, and only about a third as much storage space will be required to take care of the carcasses. Heretofore at many establishments the freezers have been more or less constantly

congested with retained carcasses, and at times more carcasses have been retained than there was room for in the available freezer space. Such conditions will be greatly relieved by the new regulations.

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SUMMARY OF TWO YEARS' STUDY OF INSECTS IN RELATION TO PELLAGRA

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With the growing interest in pellagra, following the authoritative recognition of its presence in the United States in 1907, the study of its etiology was taken up by various investigators and the several theories of causation were subjected to close scrutiny.

Prominent among these theories was that of insect transmission, first advanced by Sambon, who limited this function to the species of blood-sucking gnats comprising the genus *Simulium*.

The importance of the disease and the possibility of such a factor in its causation, led the Bureau of Entomology, late in 1911, to undertake an investigation of the subject in South Carolina, to which locality attention had been directed by the state authorities. The writer and W. V. King were, early in 1912, assigned by Dr. L. O. Howard, Chief of the Bureau of Entomology, United States Department of Agriculture, under the direction of Mr. W. D. Hunter of the Bureau, to investigate the possible relation of insects to pellagra and to gather such data as might serve to indicate whether there was ground for the assumption that blood-sucking or other arthropods were involved in the transmission of the disease in that region.

In June, 1812, the Thompson-McFadden Pellagra Commission of the Department of Tropical Medicine, New York Post-Graduate Medical School, established its laboratory and began its field work at Spartanburg, in Spartanburg County, S. C.

Through the courtesy of Capt. J. F. Siler, Medical Corps, United States Army, and with the approval of Dr. L. O. Howard, Chief of the Bureau of Entomology, the representatives of the Bureau were enabled to cooperate with the commission and to study the possible relation of insects to the causation of pellagra.

The work undertaken under these auspices consisted of a general study of such insects as appeared after a careful review of the situation to present possibilities in this connection. The species which seemed worthy of consideration were studied as to biology and habits, with special reference to the epidemiology of the disease and to the habits of those classes of the population in which appear the great mass of the cases of pellagra.

Paper read before Section K, American Association for the Advancement of Science, Atlanta, Ga., Jan. 2, 1914.

The homes of pellagrins were studied, together with the sanitary condition of their surroundings, and especially careful attention was given to the mill villages in which occur many cases of the disease.

Collections of insects were made and no effort was spared to come to an unbiased conclusion in the case of each species studied. Careful elimination of such forms as failed to meet our conception of the characteristics required was effected on the grounds set forth below.

Field work was continued until October 15, and the details of the work was published as a progress report. In April, 1913, the work was again taken up. In June, a hospital for pellagrins having been established in Spartanburg, we were afforded facilities for more elaborate laboratory studies, including the attempted transmission of pellagra to monkeys by the bites of blood-sucking insects. The details of the latter work were carried on by Mr. King and will form the basis for a later report.

As a basis for our work it was necessary to assume that pellagra is an infectious disease and that it is capable of transmission by blood-sucking insects, but it must be well understood that no positive convictions were entertained and the possibility only of such conditions is implied. In weighing the evidence as to the involvement of each insect we were impelled to apply Knab's postulate in this connection, and I shall quote its substance:

> In order to be a potential transmitter of human blood-parasites, an insect must be closely associated with man and normally have opportunity to suck his blood repeatedly. It is not sufficient that occasional specimens bite man as, for example, is the case with forest mosquitoes. Although a person may be bitten by a large number of such mosquitoes, the chance that any of these mosquitoes survive to develop the parasites in question (assuming such development to be possible), and then find opportunity to bite and infect another person, are altogether too remote.

The results of the work of 1913 were, in the main, corroborative of those of 1912, but further studies by the commission have broadened the view and introduced some new elements.

Two mill villages in counties adjacent to that of Spartanburg are equipped with an effective water-carriage system of sewage disposal. It was found that in these villages, pellagra has failed to obtain a foothold, although introduced a number of times. In the town of Spartanburg, also, there appears to be a correlation between the absence of sewers and the prevalence of pellagra.

The studies have also brought out the fact that a close domiciliary connection appears to exist between cases originating in 1912 and 1913, and older or antecedent cases; that is, the cases developing in these years, in the mill villages under consideration, which show a close household association with antecedent cases, form a large percentage of

the cases for three years. Cases which have been in less close association with older cases, such as neighbors living next door or across the street from them, form a much smaller percentage of the total. Those living at greater distances are, in some villages, wanting, the total number of such cases being very small.

That this phenomenon indicates infectiousness is so clear as to amount almost to a demonstration.

The prevalence of *Pediculus capitis* seems to be somewhat greater than we had supposed and we are led to believe that our previous views did not reflect the actual condition. This was due largely to the improved facilities for observation at our command in 1913 and partly also to the overcoming of reticence on the part of pellagra patients and their families.

The evidence gathered does not materially alter our views regarding the agency of these insects, but the fact that we had underestimated their abundance suggests the desirability of further work along this line in 1914.

The insects on which our studies were especially concentrated were the ticks, lice, bedbugs, roaches, horseflies (Tabanidae), fleas, mosquitoes, buffalo gnats (*Simulium*), houseflies and the stable fly (*Stomoxys calcitrans*).

The ticks (family Ixodidae, the only family of the group represented in South Carolina) can be safely excluded by reason of their biting habits and life history. The fact that most ticks of this family require three hosts during the life cycle, remain attached during each stage, drop to the ground at its completion and re-attach to another after molting, precludes their incrimination. So rarely could a tick remain attached to a human host a time sufficient for its engorgement and the completion of the current stage of its development, that its chances for becoming infective and living to transmit its infection would be practically *nil*. It must be borne in mind that we are dealing with a disease which shows no evidence of the existence of reservoirs of its virus among the lower animals. Ticks are not a serious pest in Spartanburg County, and those suffering most from pellagra, the home-keeping adult females and young children, are those least exposed to the bites of ticks.

The head louse was excluded by us in 1912 because its prevalence seemed inadequate to the dissemination of a disease with the epidemiologic characteristics of pellagra. The occurrence of a considerable number of cases among persons whose circumstances and habits should safeguard them from attack by *Pediculus* is opposed to the agency of the insects.

The relative incidence in males and females is not satisfactorily explained by their incrimination and the distribution of cases in the individual foci of the disease does not appear, in our opinion, strongly to indicate a flightless carrier with a human vehicle.

Notwithstanding our misconception as to the prevalence of the species, additional facts will be necessary to place it among the probable transmitters of pellagra.

In large cities, with congested populations, unhygienic surroundings and abundance of *Pediculus,* pellagra does not obtain a foothold in spite of the introduction of cases of the disease.

The bedbug, *Cimex lectularius,* although very abundant and universally distributed, when considered as a possible carrier of pellagra, does not account for certain marked characteristics of the disease. Its association with man is of the closest nature and the conditions under which a large class of pellagra suffers live, favor in high degree its indiscriminate attack on all members of the household generally. But the indiscriminate character of its attentions is the strongest argument against its incrimination.

Although the approximate ratio of infection of females to males, as a whole, in the United States is as 3 to 1, we find that among adults, nine women are victims of pellagra to every man affected. The ratio is much too high to be accounted for by an assumed selectiveness on the part of the bug by its opportunity for attack on either sex, which must be practically equal, or by a supposititious immunity of the male sex to pellagra infection.

Roaches, though common throughout the region, are negligible in connection with our subject unless the disease is found to be transmissible by means of contaminated foodstuffs. Should this be the case their rôle must still be subordinate to that of the housefly.

The family Tabanidae, which includes the well-known horse flies, should be mentioned because of their blood-sucking habits and the fact that at certain times and in some localities they attack man with a degree of frequency and persistence. These attacks are, however, desultory and have no part in the essential economy of the flies. In Spartanburg County, flies of this group were found to be far from common, and this fact together with their irregular attack on man, and an entire lack of association with him, serves to exclude them conclusively from consideration.

When attention was given to the fleas of the region, a somewhat unexpected condition was found to exist. Superficially considered, these insects might be thought to present possibilities in connection with pellagra transmission, and great care was taken to collect all possible information regarding them as well as material for study. So

uniform were negative statements as to attacks by them that we were forced to believe that as pests of human beings in the locality, fleas play but a small part. This is the less remarkable in view of the fact that we were unable to collect the human flea, *Pulex irritans,* at any time. The cat and dog fleas as well as a few chicken fleas, *Echidnophaga gallinacea,* were collected from various hosts and a number of rats, captured in the town of Spartanburg, were infested by the European rat flea, *Ceratophyllus fasciatus,* and a considerable number of the Indian rat flea, *Xenopsylla cheopis.* A few specimens of *Ctenopsylla musculi* were also obtained.

The sharply defined host habits of most fleas render the species which are characteristic parasites of cats, dogs, rats, etc., rarely troublesome to man under normal American conditions. When conditions are favorable for the inordinate propagation of the cat or dog fleas or an epizootic decimates the host species, as in plague, this may occur, but under ordinary circumstances these fleas will remain on human beings a comparatively short time and transference from man to man probably occurs but seldom. Transmission of human disease by the same channel would similarly be unlikely to occur. In addition, the sex incidence of pellagra cannot be satisfactorily explained by the incrimination of these insects.

The only mosquitoes of the region studied which justify consideration in connection with possible pellagra transmission are the two house species, *Aedes calopus* and *Culex quinquefasciatus* (fatigans). The latter species is nocturnal in habit, and its incrimination is incompatible with the sex incidence of pellagra.

While the yellow-fever mosquito is emphatically a day mosquito, its occurrence in Spartanburg County is by no means constant or regular. It should be noted that in spite of its presence in the town of Spartanburg, the species was not taken in the country districts or at points remote from railroad communication with its more southern and regular habitat. In the summer of 1912 no individuals of this species were observed, while in 1913, from June 1, the *Stegomyia* was a common and troublesome pest in Spartanburg. At the time of its appearance in 1913, the seasonal epidemic of pellagra was well advanced and the disease was showing great activity. On no accepted theory as to its period of latency, whether of short or long duration, can this species be incriminated in view of these phenomena. In spite of its day-biting habits, therefore, *Aedes calopus* must remain excluded as a causative agent.

Our studies in 1912 convinced us that there was little evidence to support the incrimination of any species of *Simulium* in South Carolina in the transmission of pellagra. Reviewing the group as a whole, we

find that its species are essentially "wild" and lack those habits of intimate association with man which would be expected in the vector of such a disease as pellagra. Although these flies are excessively abundant in some parts of their range and are moderately so in Spartanburg County, man is merely an incidental host, and no disposition whatever to seek him out or to invade his domicile seems to be manifested. Critically considered, it is nearer the fact that usually man is attacked only when he invades their habitat.

As our knowledge of pellagra accumulates, it is more and more evident that its origin is in some way closely associated with the domicile. The possibility that an insect whose association with man and his immediate environment is, at the best, casual and desultory, can be active in the causation of the disease becomes increasingly remote.

Our knowledge of the biting habits of *Simulium* is not complete, but it is evident, as regards American species at least, that these are sometimes not constant for the same species in different localities. Certain species will bite man freely when opportunity offers, while others have never been known to attack him. To assume that the proximity of a *Simulium*-breeding stream necessarily implies that persons in its vicinity must be attacked and bitten is highly fallacious. In Spartanburg County attacks by *Simulium* seem to be confined to the immediate vicinity of the breeding-places. Our records and observations, exceedingly few in number, refer almost exclusively to such locations. Statements regarding such attacks, secured with much care and discrimination from a large number of persons, including many pellagrins, indicate conclusively that these insects are seldom a pest of man in this county. A certain number of the persons questioned were familiar with the gnats in other localities, but the majority were seemingly ignorant of the existence of such flies with biting habits. This is especially striking, in view of the fact that the average distance of streams from the homes of the pellagra cases studied was about 200 yards, many being at a distance of less than 100 yards, and that 78 per cent. of these streams were found to be infested by larval *Simulium*. Such ignorance in a large number of persons cannot be overlooked and indicates strongly that our belief in the negligible character of local attacks by *Simulium* is well founded.

In localities infested by "sand-flies," mosquitoes, etc., these pests are always well known and the ignorance described above is very significant.

Such positive reports as we received nearly always referred to bites received in the open, along streams, etc., and observations made of their attack were of those on field laborers in similar situations. Males engaged in agricultural pursuits are almost exempt from pellagra

in Spartanburg County. During the season of 1913, in some two or three instances, observations were made of the biting of *Simulium* and some additional and entirely credible reports were received. These observations and reports were under conditions identical with those referred to in the reports of 1912 and confirm the conclusions based on the observations of that year. I would repeat with emphasis that it is inconceivable that a fly of the appearance and habits of the prevalent species of *Simulium* could be present in such a region, especially about the haunts of man and attack him with sufficient frequency and regularity to satisfactorily account for so active and prevalent a disease as pellagra without being a well-known and recognized pest.

In connection with the conditions in the Piedmont region of South Carolina, it may be well to cite the results of a study of those in the arid region of western Texas.

In May, 1913, in company with Capt. J. F. Siler of the Thompson-McFadden Pellagra Commission, I visited the region of which Midland in Midland County is the center. This region is very dry and totally devoid of running water for a long distance in every direction. The only natural source of water-supply, a few water holes and ponds, were visited and found to be of such a nature that the survival of *Simulium,* far less its propagation in them, is absolutely impossible. The nearest stream affording possibilities as a source of *Simulium* is 60 miles away, while the average distance of such possibility is not less than 100 miles.

Artificial sources of water-supply were also investigated carefully and were found to offer no opportunity for the breeding of *Simulium.*

At Midland the histories of five cases of pellagra were obtained, which gave clear evidence that this place or its immediate vicinity was the point of origin. Persons of long residence in the country were questioned as to the occurrence of such flies as *Simulium* and returned negative answers. These included a retired cattle owner, who is a man of education and a keen observer, an expert veterinarian stationed in the country who has the cattle of the country under constant observation, and a practical cattle man, manager of a ranch and of wide experience. The latter had had experience with "buffalo gnats" in other localities (in the East) and is well acquainted with them. His close personal supervision of the cattle under his charge, makes it practically certain that he would have discovered these gnats had they been present in the country.

At the time the study was made, *Simulium* was breeding and active in the adult state in the vicinity of Dallas, Texas, in the eastern part of the state. We have here a region in which cases of pellagra have originated, yet in which *Simulium* does not and cannot breed. Dr.

Sambon has suggested that in the absence of *Simulium* certain midges of the family Chironomidae may assume the function of transmitting pellagra.

In the course of our field work, especial attention was paid to small flies of all kinds, and although the conditions were favorable for the discovery of any blood-sucking *Chironomidae* or other midges, none were collected during the two seasons spent in the field from early spring until late fall.

The reports opposed to the frequent attacks of *Simulium* may be taken as applying also to the present group. At the risk of repetition, I would note that in the coast region of South Carolina, "sand-flies" are abundant, and are only too well known to the inhabitants.

In the course of the work of 1912, we became convinced that *Stomoxys calcitrans,* the stable-fly, which had been regarded by us merely with suspicion, was an insect which merited the closest study in connection with pellagra transmission. It is practically cosmopolitan in distribution and is found at considerable altitudes and in high latitudes. It is an abundant species almost everywhere throughout its range, and in many places is a very serious pest of domestic animals. Under favorable conditions, there are sometimes outbreaks of this fly which cause the death of many animals and untold worry and suffering to all live stock within its influence. Primarily and by preference, it preys on the larger domestic animals and breeds in their excreta. Nevertheless, it attacks man frequently and with persistence, although with some irregularity, depending to a certain extent on the presence or absence of the animals on which it usually feeds and seemingly also on weather conditions. Its association with domestic animals brings it also into somewhat close association with man, and it readily takes up a more or less prolonged residence in and about human habitations. Ample corroboration of these statements occurs in the literature of the species.

The longevity of *Stomoxys calcitrans* in nature is not known with accuracy, but experimentally the fly has been kept in confinement and fed artificially for a period of eighty-nine days. This record was obtained by W. V. King in the course of pellagra transmission experiments in 1913. The average life of the flies used in the work was much less than this, and it is highly probable that the natural life is also much shorter than three months. This species frequently attacks several hosts during the taking of a single meal, and the habit is of importance in connection with disease transmission, especially when mechanical transference of an organism is possible. The habit seems to be less a matter of choice than because of the frequency with which it is dislodged by the animal attacked. When this occurs before the

appetite is satisfied, another spot on the same animal or another is selected and a fresh bite inflicted. Experimentally fed flies usually, when undisturbed, remain attached until the completion of the meal, unless the part selected is unproductive, when the proboscis may be withdrawn and another chosen. There is great variation in the time required for complete engorgement, depending apparently on the blood-supply of the skin at that point. On man, if applied to the lower extremities, a full meal may be taken in three or four minutes, while not infrequently the fly remains as much as fifteen minutes before voluntarily withdrawing the proboscis.

In passing, it may be noted that *Stomoxys* is purely predatory in its feeding habits; it is not attracted to such substances as the nasal secretions of animals nor to carrion or offensive substances other than the excreta of the larger herbivorous animals. It is reported to breed in the feces of hogs, but in my own experience I have not observed this. I have not seen them apparently attracted to hogpens nor attacking hogs, though they doubtless do so on occasion. This species is distributed throughout the state of South Carolina, and in Spartanburg County it is very abundant. In all the cities and towns of the state it is present in large numbers and in the rural districts its abundance is even greater. Mill villages in or about which cattle are invariably kept are infested by large numbers of these flies and the usually unscreened houses are quite regularly entered by them. That the inhabitants are frequently bitten cannot be doubted as the overwhelming numbers of reports indicate. Some individuals can almost always be found in or about all houses in the mill villages of the region, and a favorite resting place is about the porches on which much time is spent by the inhabitants.

Many reports were received of attacks of *Stomoxys* on persons engaged in milking cows, and this duty falls largely on the female members of the household. A milk cow is kept by about one family in three, and the milking is done at the home of the owner to which the animal is brought, or in some mill villages, the cattle are excluded and milked and cared for in the common pasture.

When it is recalled that a high percentage of cases of pellagra occur among those who spend a large proportion of their time in or about the home, the habit of *Stomoxys* in frequenting not only the interiors of dwellings, but those parts of their exteriors which are occupied by the inhabitants is important.

Statements regarding the biting of man by *Stomoxys* were so universal in our territory and were so amply confirmed by our own experience and observations, it must be admitted that the habit is frequently practiced. It should be emphasized that man is not attacked

with the frequency and persistence displayed by such insects as the house mosquitoes, and it is not impossible that the distributional picture of pellagra may be largely accounted for by this fact. Given even a moderate degree of infectiousness and such a transmitter as the common species of *Culex,* the spread of the disease could hardly fail to be much greater and more rapid than it is known to be.

In addition to the reports received as to the biting habits of this fly, our own observations and the published statements regarding it, it seemed desirable to obtain, if possible, definite proof of the frequency with which human beings are attacked. By examination of the stomach contents of a large number of flies and determination of the species to which the host belonged it was hoped that some conclusion could be reached. The method adopted was the application of the precipitin reaction to the blood ingested by flies captured in localities where there would be reasonable opportunity for the selection by them of human hosts. More than 600 dissections were made, but the results in only about 200 of these are at present available. Of these, 109 were taken under circumstances which implied a fair chance for the fly to have recently attacked man, that is, in or about occupied dwellings, stores, etc. Six of these, or 5½ per cent., gave a positive human reaction.

In collecting the material no effort was made to select weather especially favorable for attack on man by the flies, and the days when captures were made it covered quite a wide range of meteorologic conditions.

The number of human reactions obtained may seem small, but that at one period of a few minutes at each spot, such a number of flies were found, weather disregarded, to have recently fed on human beings, appears to indicate a rather free exercise of the habit. Were it possible to capture and test all flies within the bounds of a mill village for a twenty-four-hour period, and should this ratio hold, the result from our point of view would be startling. As a matter of fact, the percentage would almost certainly fall below that mentioned and yet would, with equal certainty, represent a large number of bites with their attendant possibilities of disease transmission.

A point of interest in this series is that two of the six flies had fed on man only, three had fed also on cattle, while one gave a reaction with the sera of ox, horse and man. The blood of bovines only was determined in the stomachs of 80 per cent. of this series; of equines only, in but 6.4 per cent., while bovine and equine reaction was obtained in 7 per cent. The latter results are strongly corroborative of the observations on interrupted feeding by this species.

It has been suggested that the bite of *Stomoxys* is so painful to human beings that but a small percentage of the flies attempting to draw blood from them could succeed in doing so, and that almost all

would be driven off without attaining their object. Even if this were true it has been shown that trypanosomiasis may be communicated by the mere picking of the skin by an infected *Glossina,* even when the fly is immediately removed and no blood drawn. It may be assumed that if the parasite of pellagra is a protozoon and *Stomoxys* its carrier, that the same means may be effective.

It cannot be doubted that, almost invariably, the stable fly is driven from its human host when the pain of the bite becomes noticeable. To ascertain whether blood, even in small quantity might not have, by that time, been drawn, a series of tests was made in which clean-bred *Stomoxys* were allowed to bite selected parts of the bodies of several individuals. Such parts of the extremities as are frequently exposed were chosen and single flies confined in flat-bottomed shell-vials 25 by 100 mm., the end covered with gauze were applied to the bare skin, or in some instances the fly was allowed to bite through the stocking which covered the part. No hesitation was usually shown by the fly in proceeding to secure its meal, whether the skin was covered or bare. When the tube had been applied the subject was instructed to report the instant the first indication of pain was felt, the tube being then immediately removed and the fly dissected. Thirty-three flies were thus used, the forearm, lower leg and ankle being selected for the infliction of bites. In eleven instances, or 33 per cent. of the tests, before pain was felt, an amount of blood was drawn which ranged from one-third to a full engorgement, and in five, or almost half, a full meal was taken. In three cases on two subjects no sensation was felt at any time and the fly completed its feed and withdrew the proboscis without the knowledge of the host that a bite had been inflicted.

In many cases, the insertion of the proboscis and the early part of the process of drawing blood causes no sensation. At times when the fly is partially engorged the proboscis is thrust deeper or its position slightly changed when a more or less severe prick is felt. Were the bite incurred under natural conditions the victim would naturally assume that this was the moment of attack. The wary fly, in spite of partial engorgement, is usually able to withdraw the proboscis and avoid a hasty, ill-directed slap.

In the painless bites it is evident that anesthetic areas of the skin were selected, and analysis of my notes shows that one was inflicted one inch in front of prominence at lower end of tibia, one on external aspect of lower leg near median line and 6 inches above the ankle, the third at about the same point but 2 inches higher. This was on a different subject from the preceding.

Two other full engorgements, in which some pain was felt, were drawn from 1 inch posterior to the prominence at lower end of tibia, the other from 1 inch in front of the prominence. No painless bites

were inflicted on the forearms, but five blood-meals, ranging from one-third to two-thirds the full feed, were drawn from approximately the same areas as those already indicated.

It is of common experience that the stocking-clad ankle and parts of the leg adjacent thereto are favorite points of attack by *Stomoxys calcitrans*, even in the case of persons who are habitually shod. As far as these experiments go, they indicate that, from such parts of the body, an amount of blood may be drawn which by all analogy should be amply sufficient to cause the infection of the fly with any parasite present in it and capable of causing such infection.

House-flies are everywhere excessively abundant in Spartanburg County, houses are generally unscreened and if pellagra should prove to be communicable through contamination of food, utensils, etc., this ubiquitous pest will probably be found to play an important part in the spread of the disease.

Blow-flies are prevalent, and though far less numerous than house-flies, are, from their predilection for human excreta as a breeding-place, likely to be individually very active in such dissemination.

The facts which have come to light regarding sewage disposal by means of efficient water carriage and its seeming effect on the occurrence of pellagra, gives additional interest to the consideration of *Musca domestica* in this connection. Our present knowledge does not, however, justify a discussion of these facts or an attempt to determine whether the presence of sewers and the failure of pellagra to become active are merely coincidental and have no direct correlation; whether their effect is indirect or whether the presence of this system is a prime factor in the control of the disease. If the latter is the case, the incrimination of the house-fly seems certain.

CONCLUSION

Our studies have led us to believe that ticks, bedbugs, mosquitoes, fleas, horseflies, and, in the absence of further and more incriminating evidence, the lice, may be dismissed from consideration as transmitters of pellagra; that there is not only insufficient evidence to incriminate flies of the genus *Simulium*, but much evidence directly opposed to such incrimination and that the biting stable-fly, *Stomoxys calcitrans*, shows in marked degree those characteristics of distribution, habit and association with man which would pre-eminently fit it to be the vector of pellagra if transmission of the disease by a blood-sucking insect is shown to be possible.

If pellagra is found to be an intestinal disease of bacterial origin, house-flies and others of similar habits will in all probability be found to be an active factor in its causation.

VARIATION IN OXYURIAS: ITS BEARING ON THE VALUE OF A NEMATODE FORMULA *

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One of the most difficult problems in zoologic science is the classification of round worms. Authors and lecturers, after a carefully outlined and definitely arranged discussion of trematodes and cestodes, are compelled to consider nematodes in a somewhat desultory and inaccurate fashion. Two reasons for this may be given, the greater being the apparent lack of a basis for determining the phylogeny of the major groups, a condition with which we are not at present concerned. The other obstacle is the difficulty of differentiating between species and uncertainty as to the value of different kinds of taxonomic characters. The multitude of synonyms for many of our common insects is a sore point among entomologists, but nemathelminthologists have great difficulty in deciding that any particular name should be relegated to the synonymy.

In the absence of definite structural differences, Dujardin in 1846 found himself compelled to give a few measurements of the length, breadth, tail, etc., of the species which he described. This method was further applied by Eberth in Germany and Bastian in England, followed by Bütschli and others. Finally, in 1890, N. A. Cobb arranged a "nematode formula" which he has applied in all his subsequent work. This formula shows two kinds of measurements: first, the length of the worm in millimeters; second, the percentage of that length which is represented by the distance from the anterior end of the worm to (*a*) the base of the pharynx, (*b*) the nerve ring, (*c*) the cardiac constriction, (*d*) the vulva, and (*e*) the anus; and also the width of the body at each of these points. He uses the formulae of different species, both in descriptions and in keys for identification.

Cobb has described something over one hundred species of free-living round worms of the family Anguillulidae and has always worked out and stated the formula. As there are at present no other scientists making a specialty of this family, it would be unfair to emphasize the fact that, in the quarter century since the description of this formula, it has been used only by its originator. There are,

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* Contributions from the Zoological Laboratory of the University of Illinois, under the direction of Henry B. Ward, No. 31.

however, many helminthologists concerned with parasitic Nematoda where the obstacles of classification are equally great. Some of these have seen the possibilities of such a formula, but a real doubt as to its value has prevented them from adopting it. Until the following questions are answered, one must feel that energy and time invested in descriptions of this nature are not well employed:

1. Can the formula be applied at all to the majority of parasitic species?

2. Is the camera-lucida method of measurement sufficiently accurate for such a purpose?

3. Are the relative proportions of the different organs constant within a single species?

Cobb has not discussed these points in his published papers. He has applied the formula to very few parasitic species and apparently not at all to the difficult ones. He has published no warnings concerning the undoubted distortions caused by the varying tilt of the mirror, or the part of it from which a particular organ is reflected. In no case, so far as I am aware, does he give any indication that he has measured more than one individual of each species. This is especially noticeable in view of the fact that he must have had numerous specimens of some forms and that general attention has been called to this lack in as prominent a place as the Cambridge Natural History.

At the suggestion of Prof. Henry B. Ward of the University of Illinois, the writer recently undertook an investigation of the variation in the proportion of the organs. Incidentally, fragmentary observations on the other two questions are reported.

Cobb's measurements were made on camera-lucida drawings of cleared worms and this procedure has been modified in only one particular. Most of the worms measured by the writer were studied merely in formalin, only about one-fourth having been dehydrated and cleared in carbol xylol. None were mounted in balsam but all were studied under a cover-glass. The greatest care was used to avoid errors due to faulty technic, such as would be caused by accidental differences in the position of the camera-lucida. The effect of transfering the specimens from formalin to the clearing agent was not determined but is probably slight. The first fourteen worms whose measurements are reported in the table were cleared.

The first species of which drawings were made with a view to measurement was the hookworm, *Necator americanus* Stiles. Unfortunately, this is bent in two planes, the head being hooked at a right angle to the general body curvature. In addition, the males, of which most of the available material consisted, have the anus at the tip of

the body. The body wall is so opaque that locations of internal structure are difficult to determine, and the writer was unable to discover any method of making the nerve ring visible. For these reasons the conclusion was reached that the formula could not be satisfactorily used on these worms and work on the species was abandoned.

Accurate measurement of larger worms, such as Ascaridae, was out of the question, no apparatus adaptable to this use being available or on the market. These facts partially answer the first two problems involved, it being clear, first, that the Strongylidae, especially the hookworms, do not readily lend themselves to classification by this means; second, that the camera-lucida method of measurement now in vogue is not applicable to worms exceeding 1 cm. in length. Possibly the latter obstacle may still be overcome by the use of special apparatus if the formula proves its worth in other points.

The department of zoology then secured about one hundred specimens of *Oxyurias vermicularis* Linn., the pinworm of man. These were all from one host, living in a rural locality in Kentucky, and were all voided at the same time. It soon became clear that, among the parasitic genera, *Oxyurias* is ideal for such work. The specimens were preserved in formalin, and at first the vulva could not be located with certainty, but clearing in carbolxylol corrected that difficulty. As a consequence, the writer was able to make a rigorous test of practically all of Cobb's characters except the position of the nerve ring, which could not be determined, owing to the preservative. It may be noted in passing that the nerve ring is often difficult to locate, one of Cobb's largest papers (1893) omitting that character in the formulae of one-third of the species. Cobb gives (1890a) the formula for a young individual of *O. vermicularis*, but its immature condition invalidates any possible comparison with the results given here.

The purpose of this work was not to examine critically the particular points located by Cobb, but to ascertain the extent to which the proportions of the worm were constant, and the parts which undergo the greatest variation. The results should be of interest, both to parasitologists and to systematists, regardless of their relation to this particular formula or group.

The unit of measurement used was 1 per cent. of the length of the individual. Measurements were made on this basis from the anterior end (1) to the caudal margin of the cephalic swelling; (2) to the beginning of the esophageal bulb; (3) to the cardiac constriction; (4) to the vulva; (5) to the anus; (6) to the anterior and posterior limits of the internal reproductive organs. The width at each of these points was also determined. Finally, the total length of the worm was calculated. Fifty-two individuals were measured, but

in most of them one character or another was so indefinite that the writer did not feel justified in recording what appeared to be its location. This was especially true of the vulva, invisible in uncleared material.

The following table gives the measurements of each worm studied. In the first column is the arbitrary number of the specimen. The second gives the length of the worm in millimeters. The figures in all the other columns indicate the percentage of the length of the worm from the cephalic end to that particular point, the columns being numbered as in the last paragraph. Column 6, however, shows only the interval occupied by the reproductive organs. "L" indicates length and "W" width. Finally, for each of these *characters*, there is recorded (*a*) the average, (*b*) the number of specimens on which the character was determined, (*c*) the "standard of variation," (*d*) the maximum and (*e*) the minimum measurement found, and (*r*) the range. The average is the sum of all the measurements divided by (*b*). The standard of variation was calculated by the well-known formula, $\left(\sigma = \sqrt{\frac{\Sigma(x^2 f)}{n}}\right)$, x being the deviation of a class from the average, and *f*, the number in the class. The range is merely the maximum, (*d*), minus the minimum, (*e*).

Attention should be called to the fact that results (*a*) and (*c*) were calculated from measurements to the second decimal place. In order to limit space it was thought desirable to omit the second place in the printed record. This will explain any slight discrepancies which might confuse, should these results be checked over. The lack of value of the second or even the first decimal place is discussed in a later paragraph.

The average length of the body of this species is 7.39 mm. The range is about one-fourth of the maximum length. As the curve is normal, the total range in the species is probably not much greater than this.

1. The *external cephalic swelling* is peculiar to the species studied and is a secondary development of no great definiteness or importance. The curve of the variation in its length is an irregular one and far from the normal type. It will be noted that the range is over two-fifths of the maximum, and that the standard of variation is 0.397 per cent., or about one-ninth of the maximum. In view of the nature of this feature, considerable variation was to be expected.

2. The *esophageal bulb* marks a distinct division of the alimentary canal and is bounded by two definite constrictions. The esophagus, which leads from the mouth to this bulb, is straight or slightly bent, in no case being sufficiently curved to draw the bulb out of its position. Variation is from 8.3 per cent. to 12.1 per cent., a range of 3.8 per cent.

No.	L in mm.	1		2		3		4		5		6	
		L	W	L	W	L	W	L	W	L	W	Interval	No.
1	7.05	2.2	2.6	9.5	4.8	11.7	5.3	24.1	6.4	77.5	3.1	69.5	1
2	7.37	2.4	2.0	10.0	3.5	12.3	3.7	31.4	5.2	79.5	3.2	61.9	2
3	7.97	2.7	2.1	9.7	4.2	12.2	4.4	30.1	5.3	78.8	2.0	62.1	3
4	7.51	2.3	2.0	9.9	4.2	12.5	5.1	26.8	5.6	78.2	2.3	....	4
5	....	3.0	2.0	9.4	3.9	12.1	4.4	29.2	6.3	79.2	3.4	....	5
6	7.75	3.4	2.1	9.4	2.8	12.1	3.4	31.9	4.5	79.3	1.9	....	6
7	6.87	2.9	2.1	10.9	3.9	13.4	4.3	...	...	74.5	3.1	60.3	7
8	7.20	3.3	1.8	10.1	2.9	12.4	3.1	33.6	...	78.8	2.1	....	8
9	8.35	3.0	1.7	9.1	2.9	11.4	3.2	23.7	...	78.9	2.5	....	9
10	7.74	2.4	2.3	9.2	4.2	11.2	4.5	29.2	5.6	...	...	73.3	10
11	6.41	2.4	2.6	...	...	...	...	23.1	5.9	74.8	3.2	....	11
12	6.93	3.2	2.5	9.9	4.6	11.9	5.0	27.3	7.4	...	...	....	12
13	6.74	2.5	2.1	...	4.3	...	4.6	23.3	5.3	...	...	....	13
14	7.80	2.1	2.4	...	...	...	...	25.9	5.8	79.2	2.9	67.5	14
15	8.10	2.9	2.3	10.0	3.9	12.4	4.4	...	...	78.0	3.1	66.3	15
16	8.15	2.6	2.1	8.8	3.9	11.1	4.1	...	...	76.7	3.2	66.8	16
17	7.17	2.3	2.3	10.5	4.8	13.1	5.4	...	..	76.8	3.0	64.8	17
18	6.45	3.1	1.8	8.7	2.9	10.8	3.0	..	...	79.8	2.3	58.8	18
19	7.32	2.5	2.5	...	...	...	...	...	...	76.3	2.6	64.7	19
20	7.32	3.0	2.4	10.1	4.0	12.5	4.5	...	...	76.1	3.2	60.2	20
21	8.60	2.7	1.8	9.1	3.4	11.6	3.9	...	...	...	...	....	21
22	6.87	2.3	2.6	12.1	4.9	14.2	5.2	...	...	76.6	3.2	....	22
23	6.93	2.4	2.5	11.1	4.1	14.0	4.4	...	...	75.6	2.9	....	23
24	7.05	2.6	2.8	10.5	4.5	12.9	4.8	...	...	78.5	3.5	....	24
25	6.85	2.4	2.6	11.2	5.8	13.4	6.3	..	...	77.5	2.8	66.8	25
26	7.46	3.1	2.1	9.9	3.2	12.2	3.5	...	...	80.6	3.6	37.5	26
27	7.71	2.4	2.2	10.4	4.8	...	...	...	...	74.2	3.6	63.8	27
28	6.67	3.4	2.4	11.4	3.9	14.4	4.5	...	...	...	...	51.0	28
29	7.02	3.6	1.6	10.3	2.4	13.0	2.4	...	...	77.6	2.1	....	29
30	6.50	..	..	8.3	2.8	10.4	2.9	...	...	81.4	2.1	....	30
31	7.53	3.2	1.6	9.0	2.3	11.2	2.5	...	...	79.2	2.1	....	31
32	6.60	3.4	1.8	9.7	2.5	12.5	3.2	...	...	79.9	2.0	34.4	32
33	7.82	2.6	2.3	9.0	3.9	11.0	4.5	...	...	77.0	3.2	76.1	33
34	6.74	2.9	1.9	9.0	2.6	11.6	3.1	...	...	79.2	2.0	35.2	34
35	7.35	3.2	1.9	9.2	3.7	11.1	3.9	...	...	79.5	2.8	59.2	35
36	8.37	2.9	1.9	9.6	3.8	12.2	3.9	...	...	75.5	3.1	73.9	36
37	7.52	3.3	2.0	10.0	3.1	12.4	3.3	...	...	76.7	...	34.9	37
38	7.47	3.0	1.8	9.7	2.4	11.9	2.5	...	...	77.2	...	....	38
39	6.94	...	...	10.7	2.6	12.9	2.8	...	...	75.8	3.1	38.2	39
40	7.25	...	...	9.8	3.6	12.1	4.1	...	...	78.3	2.4	46.2	40
41	7.00	..	...	11.0	3.1	13.8	3.4	...	...	78.0	2.3	42.5	41
42	8.05	2.8	2.0	9.0	2.9	11.1	3.2	...	...	81.2	2.4	50.5	42
43	7.96	2.7	1.9	8.5	2.8	11.0	3.3	...	...	80.6	2.5	40.6	43
44	8.35	2.6	2.4	10.0	4.5	12.3	4.9	...	...	77.0	3.3	....	44
45	7.03	2.1	1.6	9.6	3.2	12.0	3.4	...	...	81.2	2.3	47.4	45
46	7.40	2.9	1.8	9.5	2.9	11.7	3.1	...	...	80.2	2.3	....	46
47	7.96	2.9	2.1	8.9	3.0	11.9	3.1	...	...	78.8	3.0	....	47
48	7.20	3.0	1.8	9.2	2.7	11.7	3.1	...	...	80.5	2.0	....	48
49	8.50	2.7	1.7	8.6	2.9	10.6	3.3	...	...	78.4	2.3	....	49
50	....	2.4	2.2	9.3	4.0	11.5	4.4	...	...	76.8	3.2	63.5	50
51	....	2.9	2.5	10.0	4.6	12.8	5.0	...	...	77.1	3.1	65.2	51
52	....	3.7	2.5	9.5	4.0	12.2	4.4	...	..	77.2	3.1	....	52
(a)* Av.	7.39	2.8	2.1	9.8	3.2	12.2	3.9	27.6	5.8	78.2	2.7	56.1	Av.
(b) No. spec.	49	48	48	48	49	47	48	13	11	48	46	30	No. spec.
(c) σ	.584	.397	.314	.714	.878	.896	...	3.37	.757	1.78	.468	....	σ
(d) M	8.60	3.7	2.8	12.1	5.8	14.4	6.3	33.6	7.4	81.4	3.6	75.1	M
(e) m	6.41	2.1	1.6	8.3	2.3	10.4	2.4	23.1	4.5	74.2	1.9	37.5	m
(r) M-m	2.19	1.6	1.2	3.8	3.5	4.0	3.9	10.5	2.9	7.2	1.7	37.6	M-m

The magnitude of the range and of the standard of variation is striking.

3. The *cardiac constriction* is the caudal limit of the esophageal bulb, which occupies from 2 to 3 per cent. of the length of the worm. The distance of this constriction from the mouth varies from 10.4 to 14.4 per cent., and the range, 4 per cent., is about two-sevenths of the maximum. This range overlaps about one-sixth of all the species Cobb has described in the papers at hand.

4. Only thirteen individuals were studied in which the vulva could be located, it being invisible in the opaque formalin material. In the cleared specimens, the range in its position was about one-third of the maximum distance from the mouth. The standard of variation, 3.37 per cent., is over four times that of any of the first three structures.

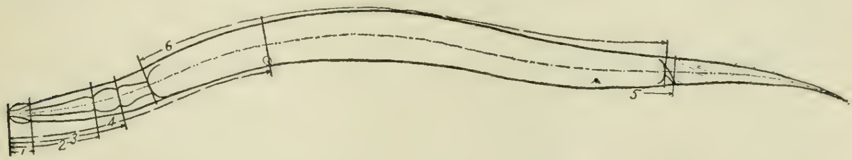

Fig. 1.—*Oxyurias vermicularis* Linn. Specimen No. 2; lateral aspect of cleared worm. 1-6, the structures and distances measured in this paper; for explanation see text, and table opposite.

5. The anus is usually located in the caudal fourth of the body, its position varying from 74.2 to 81.4 per cent., a range of 7.2 per cent. The standard of variation is 1.78 per cent., or midway between those of the last two structures. Some reliance, therefore, can be placed on measurements of the location of the anus.

6. In the use of the formula, the interval occupied by the reproductive organs is given in an approximate and general way. Cobb usually uses a multiple of 10 per cent. to express this distance. Even this approximation, however, appears to be of no value in *Oxyurias*. In some cases these organs reach from a point near the mouth (5.7 per cent.) to a point behind the anus (86.9 per cent.), often obscuring the latter's position. In other specimens they have shrunken to a small size or are undeveloped. The interval occupied varies from 37.5 to 75.1 per cent., a range of 37.6 per cent. Such a condition makes the recording of this interval in the specimens at hand when a species is described a waste of labor.

While measurements of the lengths of different structures vary independently of each other, this is not true of the widths at different points. For this reason separate discussions of the latter are not necessary. In almost all cases the range in widths is approximately equal to, or greater than, the width of the most slender worm studied. So few specimens were measured at the vulva that the range there is

not as great as it should be, neither the slimmest nor plumpest worms having been measured at this point. Taking the width at the cardiac constriction as typical, we find a variation of from 2.4 to 6.3 per cent. The latter worm was particularly contracted, however, the normal range being from 2.4 to 5.4 per cent., as shown by the curve of variation.

If structures were correlated with each other, considerable reliance could be placed on the body proportions in spite of the individual variation. It was hoped that a study of correlation would yield results which would assist in the interpretation of the relation between an unnamed specimen and a given formula. The attempt to find such assistance, however, must be considered a failure.

Correlation diagrams were made to show the relation of the width of the body to the length of the esophagus, the length of the alimentary canal to the length of the esophagus, the relation of the position of the vulva to that of the anus and to that of the cardiac constriction, etc. In no case was there the least indication of correlation, except between the length of the esophagus and the position of the cardiac constriction. As the esophageal bulb which separates these is small and rather constant in size, this fact can hardly be called a true correlation.

Much of the importance of a study of variation in its relation to classification depends on the differences between the various species with the group concerned. Thus, if all Nematoda had an esophagus about one-eighth the length of the body, had the vulva placed within the cephalic third, and the anus near the beginning of the caudal fourth of the total length, a variation no greater than occurs in *Oxyurias* would make the measurement method valueless in identification. The formulae of about one hundred species described by N. A. Cobb were, therefore, examined in order to determine the variation within the class. In some cases curves were plotted.

This examination showed an ideal condition for such a scheme. A curve including the formulae of the described species is similar to a long, low mountain range. All possible changes in the proportions seem to have been observed. As a result, the range of each of the characters given above covers only one-fifth to one-tenth of the described species. In some cases it is less than that. For example, the vulva, in the eighty-five species whose descriptions happen to be before me at the moment, varies from 20 to about 80 per cent. in position. Of these, only five species are between the maximum and minimum found in the specimens of *Oxyurias* reported in this paper. Forty of them, however, or nearly half, are between 45 and 55 per cent., a range less than that in this species. The fact, therefore, that the range appears unimportant in this case seems to be an accident of the species chosen.

In tables for identification, Cobb has used such characters as "Tail 15 per cent.," as opposed to "Tail 20 per cent."; or "Body slender (little more than 2.6 per cent.)" in opposition to "Body not so slender (3 per cent. or over)." In these and many other places the difference specified is less than the range in this one species.

In general, the variations recorded here may be due to two causes: (*a*) varying state of contraction owing to chemical technic, conditions of killing, etc., and (*b*) ordinary fluctuating variations. General body contraction would not affect the positions of the organs and can scarcely account for differences in length percentages. On the other hand it would have an important effect on the width. Thus the length percentages, depending largely on fluctuating individual variations, are not correlated with the widths, most of which are determined by the state of contraction. The impossibility of securing uniform contraction makes it necessary to consider width measurements unreliable.

In the practice of identification of specimens two advantages may be claimed for a formula. In the first place it is an abbreviated record of what would be a long description. This advantage cannot be gainsaid and is the principal source of the strength of the "nematode formula." In the second place a comparison of the formula of a specimen at hand with those of a series of descriptions might aid in identification. This is the advantage which has been emphasized too much. The following are the formulae of a few of the specimens of *Oxyurias vermicularis:*

No. 1.	2.2	9.5	11.7	24.1^{70}	77.5	7.05 mm.
	2.6	4.8	5.3	6.4	3.1	
No. 2.	2.4	10.0	12.3	31.4^{62}	79.5	7.37 mm.
	2.0	3.5	3.7	5.2	3.2	
No. 7.	2.9	10.9	13.4	$?^{60}$	74.5	6.87 mm.
	2.1	3.9	4.3	?	3.1	
No. 26.	3.1	9.9	12.2	$?^{37}$	80.6	7.46 mm.
	2.1	3.2	3.5	?	3.6	
No. 42.	2.8	9.0	11.1	$?^{50}$	81.2	8.05 mm.
	2.0	2.9	3.2	?	2.4	

These figures do not refer to the exact points used by Cobb, but the principle is the same. If the species had been described from No. 7 and that formula given as typical, it is doubtful whether it would aid in naming No. 26 or any of the others.

CONCLUSIONS

The proportionate size of the organs in *Nematoda* is an important factor in their identification and should be stated in any description of a new species.

The locations of the cephalic parts of the alimentary canal tend to vary from 1 to 4 per cent., about one-third of the maximum, in *Oxyurias vermicularis*.

The location of the vulva probably varies at least 15 per cent. in a long series of individuals.

The location of the anus varies over 7 per cent., or about one-third of the length of the tail.

Variations in width are so great that some individuals are over twice as wide as others.

The length of the body of some individuals is one-third greater than that of others.

The use of the formula is likely to yield more confusion than assistance. It is impossible to indicate the observed range, and without that the numbers are meaningless. Carrying the measurement to one-tenth of 1 per cent., gives an appearance of accuracy which does not exist. The formula is likely to result in the multiplication of so-called species without a proper basis for their separation.

A species should not be described as new on account of a deviation from the proportions of known species unless that deviation is great and fundamental. The space occupied by the reproductive organs should not be considered, and little dependence should be placed on the width of the body. From four to ten individuals should always be studied and the observed range recorded. In this way the varying proportions of the different species can be used in the identification of collected specimens. An individual should never be identified, however, on the basis of the formula alone or of the proportions alone.

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OBSERVATIONS ON THE EGGS OF ASCARIS LUMBRICOIDES

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The appearance of the ova of *Ascaris lumbricoides* as seen in fresh feces is so well known to physicians and zoologists that description is unnecessary. Occasionally, however, ascarid eggs are found which differ so widely from the normal egg of *Ascaris lumbricoides* as to cause considerable confusion on the part of observers, and may even be so misleading in appearance as to be attributed to another species. One of these atypical forms, the unfertilized egg of *Ascaris lumbricoides,* first reported by Miura and Nishiuchi (1902), is by no means rare, and is usually seen in the feces of persons infested with female parasites only (Fig. 1).

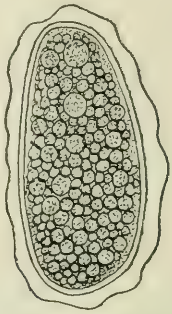

Fig. 1.—Unfertilized egg of Ascaris lumbricoides. After Miura and Nishiuchi, 1902.

Another atypical egg, differing from the normal egg only in size, has an exceptionally long major axis, while its width is no greater than that of the average egg, thus giving it a narrow elliptical form instead of the broad oval of the average egg. A sample of feces received from Florida contained numbers of eggs of this form, no eggs of average size being present. In this case the variation from the normal egg was so marked that it was only after having observed similar eggs known to have come from *Ascaris lumbricoides,* I could be certain of the identification. Although not reported in the literature, except for a brief note by the writer (Foster, 1913), this type of ascarid egg is apparently not rare. Drs. Stitt and Garrison, in conversation with the writer, reported seeing this atypical form in feces in Manila, while Dr. Stiles told the writer that he had seen several cases while engaged in hookworm work in the Southern states. The appearance of the

elongated egg contrasted with the normal egg is shown in Figures 2 and 3.

As the result of the measurement of over 200 eggs, half of which were derived from dissections of ascarids from man and half from ascarids of pigs, I find that there is no sharp demarcation between the excessively long egg and the average egg, but specimens can be found making a complete series. By averaging all eggs having the same

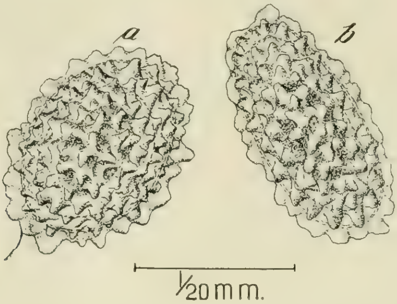

Fig. 2.—Superficial view of eggs of *Ascaris lumbricoides*. *a*, normal egg; *b*, elongated form.

length but different diameters, and arranging the results in the order of increasing length, it was found that the diameter remained fairly constant as the length of the egg increased. It follows as a corollary

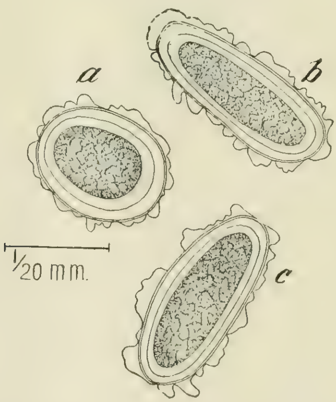

Fig. 3.—Eggs of *Ascaris lumbricoides* seen in optical section. *a*, normal egg; *b* and *c*, elongated forms.

that as the length of the eggs of *Ascaris lumbricoides* increases, the ratio of the diameter to the length steadily decreases. This rule was found to apply both to those eggs derived from ascarids from swine and to those from man. There are of course many slight exceptions to this rule, but if a sufficient number of eggs are measured to serve as

a fair basis of comparison, it will be seen that but little variation is found in the diameter of the eggs measured, while the length may vary throughout a range of 51 microns between the shortest and longest egg. When ratios are considered, instead of actual measurements, the exceptions to the corollary of the rule are very few, since individual variations are largely neutralized when expressed in terms of relative values.

The accompanying diagram (Fig. 4) shows how little variation is seen in the diameter of ascarid eggs, compared to the great variation in length. In the left-hand column, representing measurements of ascarid eggs from swine, there is a variation of 29 microns between the maximum and minimum length, although both extremes have the same diameter, which is only 7 microns less than the average diameter of all eggs measured. In the right-hand column, representing the longest and shortest egg seen in ascarids from man, there is a difference of 51 microns between the maximum and minimum lengths, while the diameter of the longest egg is actually 8 microns less than that of the shortest egg and is 12 microns less than the average diameter of all eggs measured.

The fact that all eggs, no matter what their length, have a fairly uniform diameter, would seem to be based on some morphologic structure of the female genital tract. If at some point in their development, the eggs, while still in a plastic condition, were forced lengthwise through a narrow lumen admitting only one egg at a time, we should expect to find all the eggs of a given worm having approximately the same diameter. It is evident that this modification cannot take place in the vagina, for although eggs usually pass out of the vagina in single file, dissection of the uterus shows the extremely long eggs and average eggs all having approximately the same diameter, in the proximal portion of the uterus before the eggs have passed through the vagina. Besides, the muscular wall of the vagina will expand to accommodate itself to the different diameters of the eggs rather than force them to conform to its own diameter, since the chitinous shell allows of very little if any compression. The modifying influence, if any such is present, must therefore be exerted at some point in the genital tract before the egg receives its shell, or while in the process of shell formation. As Leuckart (1867) calls attention to the fact that eggs in the posterior uterus before their shells are fully formed have approximately the same diameter though varying in length, it occurred to the writer that this modifying influence might take place as the eggs pass from the receptaculum seminis, the region immediately posterior of the uterus, into the uterus. The receptaculum seminis is separated from the uterus by a narrow sphincter-like constriction described by

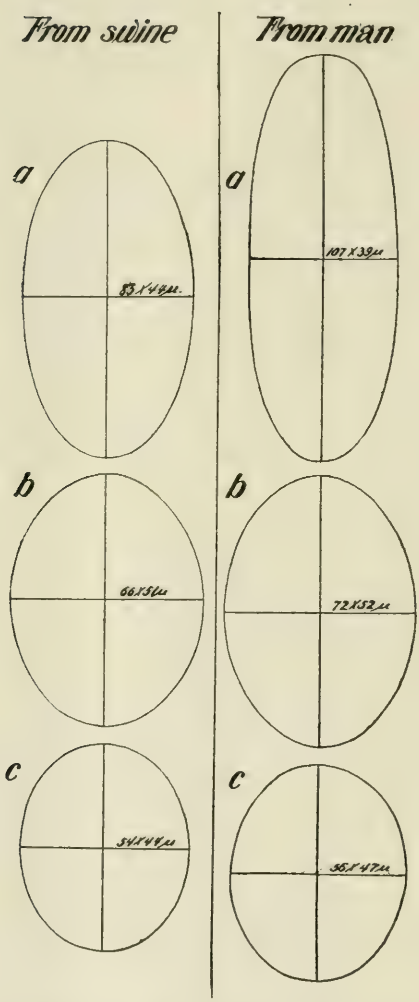

Fig. 4.—Diagram based on measurements of over 200 ascarid eggs from man and from swine, illustrating the principle that the diameter remains fairly constant as the length of the eggs increases. *a,* eggs of maximum length, from swine and from man respectively; *b,* eggs of average length; *c,* eggs of minimum length.

Leuckart (1867) and at this point the eggs are still plastic, as they do not receive their shells (according to Blanchard, 1888) until the eggs have traversed the posterior half of the uterus. Cross-sections of this sphincter, however, show that its lumen, while considerably narrower than the preceding or subsequent parts of the genital tract, is sufficiently large to allow many eggs to pass through at one time. The writer has examined cross-sections of the entire posterior half of the uterus without finding any place where the eggs when in a plastic condition would be subjected to pressure tending to give them a uniform diameter.

While the uniform diameter of eggs from the same worm may be explained by some such morphologic modification as suggested above, it is harder to explain the fact that eggs from different worms varying greatly in size, have approximately the same diameter. It is hardly reasonable to assume that the lumen of the genital tract in different worms would have approximately the same diameter at the same place, for since the external measurements of different adult individuals is subject to great variation, we should expect and in fact do find, corresponding variations in the measurements of the internal organs.

Table of measurements of eggs of *Ascaris lumbricoides* from man and from swine, arranged in order of decreasing length, to show that as the length decreases, the width remains constant or slightly increases. Measurements in microns. Each set of measurements represents the averages of five individual eggs from the same worm. In those cases where the measurements have the same length but different widths, the corresponding ratio is the ratio of the average width to the given length.

TABLE 1.—From Swine			TABLE 2.—From Man			TABLE 3.—Combined from One and Two		
Length	Width	Ratio	Length	Width	Ratio	Length	Width	Ratio
73.0	56.5	72.1	87.5	49.0	56.0	87.5	49.0	56.0
73.0	49.0		78.0	46.5		78.0	49.5	63.5
70.5	51.5	71.3	78.0	51.5	63.5	75.5	57.5	76.2
70.5	49.0		78.0	50.5		73.0	54.0	74.0
68.0	56.5		75.5	57.5	76.2	71.5	55.5	77.6
68.0	54.0	81.3	73.0	56.5	75.3	71.0	51.5	72.5
68.0	56.5		73.0	54.0		70.5	51.0	72.3
66.0	50.5	76.5	71.5	55.5	77.6	69.0	49.0	71.0
65.5	49.0		71.0	51.5	72.5	68.0	53.0	77.9
65.5	54.0	81.0	70.5	51.5	73.0	66.0	50.5	76.5
65.5	56.5		69.0	49.0	71.0	65.5	51.0	77.9
64.5	45.0	69.7	68.0	51.5	73.4	65.0	54.0	83.1
63.5	47.5	72.6	68.0	49.0		64.5	49.0	76.0
63.5	45.0		65.5	48.5	74.0	63.5	49.5	78.0
62.5	52.5	84.0	65.0	54.0	83.0	62.0	51.0	82.3
62.0	49.0	79.0	64.5	52.5	81.3	61.0	47.5	77.9
61.0	47.5	77.8	63.5	59.5	73.2	56.5	46.5	82.3
56.5	46.5	82.3	63.5	46.5				
			62.0	53.0	85.4			

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DR. NOTT'S THEORY OF INSECT CAUSATION OF DISEASE

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The danger in using isolated sentences from an article as a basis for interpreting the author's theories, is generally recognized, but sometimes the most careful workers fall into the trap. Once the mistaken interpretation is published, it may be copied over and over again until it rises to the dignity of a dogma.

A striking illustration is afforded by the practical unanimity with which writers on the subject of insects and disease credit Dr. Josiah Nott with being the earliest to formulate definitely the theory of mosquito transmission of yellow fever.

Nuttall, in his classic monograph "On the Rôle of Insects, Arachnids and Myriapods as Carriers in the Spread of Bacterial and Parasitic Diseases" (1899), states: "In 1848, Nott of New Orleans published an essay on yellow fever, in which he refers to malaria *as if the mosquito theory had already been advanced,* and he gives grounds for his belief that the mosquito also gives rise to yellow fever."

The original publication was not accessible to Dr. Nuttall, who was forced to depend on an abstract furnished by Dr. Isadore Dyer of New Orleans. Following Nuttall, almost every writer on the historical aspect of the theory of insect transmission of disease, especially yellow fever, refers to Nott's theory, and some who have evidently seen and hurriedly read the original, quote specific statements which seem to indicate clearly the intent of the argument.

Dr Nott's scholarly paper on "The Cause of Yellow Fever" was published in the *New Orleans Medical and Surgical Journal,* vol. iv, in March, 1848. A cursory reading of it, in the light of present-day knowledge, affords ample indication that he believed in the insect transmission not only of yellow fever, but also of malaria and various other diseases. For instance, one could hardly draw any other conclusion from reading such isolated statements as:

"The morbific cause of yellow fever is not amenable to any of the laws of gases, vapors, emanations, etc., but has an inherent power of propagation, independent of the motions of the atmosphere, and which accords in many respects with the peculiar habits and instincts of insects.

"There are even perfectly authenticated instances where one side or end of a ship has suffered severely from the disease while the other was entirely free from it. We can readily believe that certain insects which are endowed with unaccountable instincts and habits, might attack a part of a ship, of a

tree, of a wheat or cotton field, but we cannot imagine how a gas could be turned loose on one side of the cabin of a vessel and not extend to the other.

"It would certainly be quite as philosophic (as the malarial theory) to suppose that some insect or animalcule hatched in the lowlands, like the mosquito, after passing through its metamorphosis takes flight and either from a preference for a different atmosphere, or impelled by one of those extraordinary instincts which many are known to possess, wings its way to the hill top to fulfil its appointed destiny."

Explicit as these statements seem, they can be interpreted only when we remember that Nott wrote at a period before Pasteur and Koch had completely revolutionized the ideas of medical men regarding the causation of disease, and that he was in reality presenting a masterly argument in favor of a germ theory of disease. No one can read the entire article, in its proper historical setting, without realizing that Dr. Nott used the term "insect" to denominate micro-organisms, and that his explicit references to true insects were merely for the purpose of illustrating the propagation, methods of development and habits of the invisible "insects" or "animalcules" whose existence he postulated.

He did speak of "the perfect analogy between the habits of certain insects and yellow fever," but he had no more intention of urging that the disease was mosquito borne than that it was carried by the aphids, Hessian flies or cotton worms that he also cites for illustration.

If, after reading the full article, additional evidence is desired, it is furnished in a conclusive manner by going still further back. Dr. Nott takes pains to explain that "there is no novelty in the doctrine of the insect or animalcule origin of disease" and states that "the most elaborate and ingenious article I have met with is that in Sir Henry Holland's Medical Notes, "On the Hypothesis of Insect Life as a Cause of Disease."

On referring to that interesting book, printed in 1839, we find that Dr. Holland raises the question as to "what weight we may attach to the opinion that certain diseases, and especially some of epidemic and contagious kind, are derived from minute forms of animal life, existing in the atmosphere under particular circumstances."

His use of the term "insect" is illustrated by the statement:

"It is only of late that the wonderful eye of the microscope has clearly disclosed to us that vast domain of life to which the infusoria belong; a new world which might have remained forever as much hidden from our sense and knowledge as the *invisible forms of insect life,* of which the hypothesis before us presumes the existence.

"If existing, the same analogy will lead us to other inferences, not less probable, as to those habits and instincts, in which they may be presumed to have affinity for the known insect genera. Such are their frequent sudden generation, at irregular and often distant periods, under certain circumstances of season or locality, or under other conditions, less obvious to apprehension. Secondly, the diffusion of swarms, so generated, and with rapidly repeated

propagation, over wide tracts of country, and often following particular lines of movement. To which general inferences may be added another (resting on analogy, though of less explicit kind), namely, that certain of these animalcule species may act as poisons, or causes of disease.

"Whatever is true as to the habits of insects obvious to our senses, is likely to be more especially so in those whose minuteness removes them further from observation." (Italics mine.)

It was to the support of this hypothesis of causation of disease by micro-organisms and this alone, that Nott brought a wealth of observations on yellow fever and malaria, and he deserves full credit for the logical manner in which he analyzed and presented his data.

RHABDITIN

CONTRIBUTION TO A SCIENCE OF NEMATOLOGY

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Rhabditin is the term applied by the writer to an organic substance, the type form of which is found crystallized in brilliantly doubly refractive spheres arranged in a definite way in the cells of the intestine *Rhabditis monhystera* Bütschli, and other nematodes, in whose metabolism it plays an important rôle.

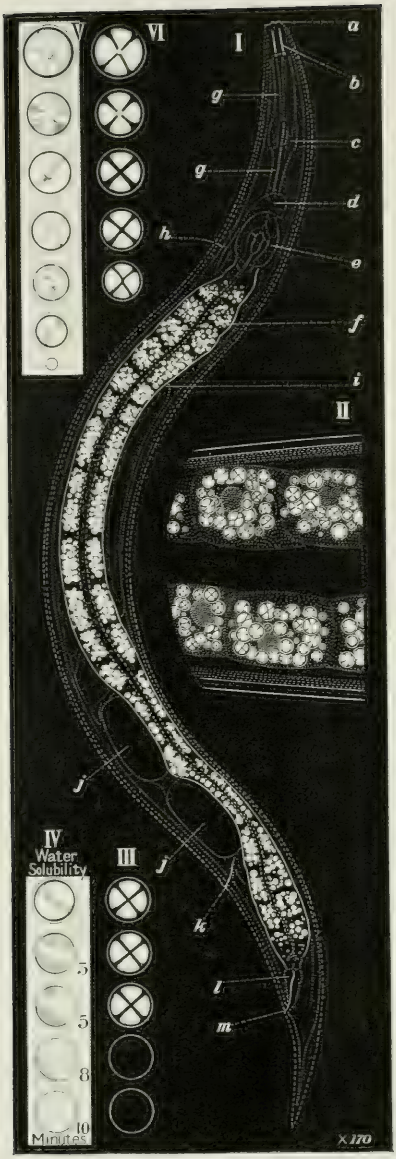
Rhabditin crystallizes under the life influences of *Rhabditis monhystera* into spheres, about 1 to 3 microns in diameter, which are rather slowly soluble in water, rapidly so in alkalies and acids — in the latter without effervescence — and are insoluble or but very slowly soluble in alcohol, glycerin, xylol and oils. The aqueous solution gives no precipitate with barium chlorid or barium hydrate. The crystals do not change essentially in optical properties (do not melt or dissolve) when the nematodes are fixed in boiling absolute alcohol.

When disintegrating in water the internal parts of the spheres first dissolve, leaving in the course of five to thirty minutes shells (plasts?) which are not doubly refractive, and which stain readily and strongly in solution of gentian violet, less strongly in aqueous safranin. The crystals, when freshly removed from the tissues of the nematode and placed immediately in the violet, while strongly stained externally, do not appear to be stained in the internal doubly refractive part, the "maltese cross" of which appears brilliant and unstained when viewed with crossed Nichols. Rhabditin does not stain in iodin-potassium-iodid solution.

In a microscopic test the crushed bodies of *Rhabditis monhystera* reduced Fehling's solution, and it seemed probable that rhabditin was the main if not the sole reducing agent.

When the spheres are undergoing brownian movements they prove to be doubly refractive in every view, though the maltese cross occasionally "blinks," as if in one particular direction this property is less pronounced.

In *Rhabditis monhystera* the crystals of rhabditin are arranged in relatively large groups round the centrally located nuclei of the intestinal cells, and sometimes constitute a large fraction of the mass of the cells. They are absent, or infrequent, in the initial intestinal cells



Female *Rhabditis monhystera* Bütschli viewed with polarized light. I. Lateral aspect. II. Section of worm more highly magnified, showing intestinal cells, their nuclei, and crystals of rhabditin. III and IV. Crystals of rhabditin in process of solution in water. Note that the maltese cross remains undiminished in brilliancy even when a large proportion of the rhabditin has been dissolved, indicating that the solution takes place from the center outward. V and VI. Crystals of rhabditin showing the comparative appearance of crystals of various size when seen without polarized light.

a, lips; *b*, pharynx; *c*, median bulb; *d*, nerve-ring; *e*, cardiac bulb; *f*, intestine; *g*, posterior portion of esophagus; *h*, excretory pore; *i*, flexure in ovary; *j*, *j*, eggs; *k*, vulva; *l*, rectum; *m*, anus.

— the few immediately behind the cardia. They may be found in each of the other cells of the intestine, but are then likely to be a trifle less numerous in the final cells. They do not occur in any other cells of the body. In some other species they occur less generally, sometimes only in a part of the intestine, and sometimes as "double" spheres.

When the bodies of *Rhabditis monhystera* are incinerated no trace of rhabditin remains; when the bodies containing a large amount of rhabditin are burned in a Bunsen flame in front of the spectroscope, only a very faint flickering sodium band is to be seen, indicating the absence of the earthy constituents that might be expected in certain excretory salts, for example, calcium.

From the foregoing tests it will be seen that the present indications are that rhabditin is a carbohydrate, though it seems out of harmony with this supposition that the crystals do not decrease materially in number or size when the nematode containing them is placed on a starvation basis in distilled water for seven days. During this time other granules in the same cells, believed to be fatty substances, disappear. Its isolation in sufficient quantity for more complete tests will be a difficult matter.

Rhabditin occurs in embryos, even very young ones, in comparatively early stages of their segmentation, and the future intestinal cells may sometimes be distinguished from other cells by what appear to be exceedingly minute crystals of rhabditin.

Rhabditin has been noted by various investigators under the name of "granules," for the most part merely so indicated in drawings, without comment, except where indicated merely as a means of species characterization.

With the crystals of rhabditin there often occur other granular bodies of a different nature.

EXPERIMENTAL INGESTION BY MAN OF CYSTICERCI OF CARNIVORE TAPEWORMS

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Having experimentally eaten the larvae of dog tapeworms on two occasions, I undertook to look up the literature on this subject in connection with the ingestion of *Cysticercus pisiformis* to check the frequently quoted record of *T. pisiformis* from man. I find that there are more cases of the sort than I had supposed, so I have collected these cases in connection with a recent similar case of my own.

Taenia pisiformis, under the name of *T. serrata,* has been recorded as a parasite of man by Vital (1874), who records, in effect, two cases. One was a case of intestinal taeniasis in a native Algerian, reported under the paragraph heading (translated) Two taenias in the digestive tract, one of which has the appearance of *Taenia serrata.* These tapeworms were collected post mortem. He states that one tapeworm was undoubtedly *T. solium.* The other was 1 meter long and 6 mm. broad, the segments attached in such fashion as to present a saw-toothed aspect. The thick rostrum was armed with hooks, and a single lateral genital pore was noted in the segments. There are no further data on this case.

A footnote reference states that *T. serrata* has recently been collected at Constantine (the locality for Vital's case also) in company with two specimens of *T. saginata* from a young woman by the use of pumpkin-seed as a vermifuge. Parenthetically, he remarks that the worms were examined by Dr. Cauvet. Two months later, Cauvet published in the same journal (*Gazette médicale de Paris*) a note on the tapeworms found in Algeria. In this note he lists and discusses *Bothriocephalus, T. solium* and *T. saginata.* He says nothing whatever about *T. serrata,* and it seems safe to assume that any statements he may have made regarding a worm from man being *T. serrata* were not based on careful examination and were not intended for publication.

It is quite impossible to identify *T. serrata* by any such casual method as Vital used. Parasitologists who have mentioned Vital's cases have regularly regarded them as doubtful or erroneous. Moniez (1896) states that neither Vital nor Cauvet can be considered as authorities. He adds that he has fed *Cysticercus pisiformis* to two volunteer human subjects without developing the tapeworm. Galli-Valerio (1898) states that he once ingested six of these larvae. This occasioned a slight stomachache that night, possibly due to toxins in the

cysticerci, but no tapeworm development was noted in spite of fecal examination and the use of male fern as a vermifuge. During the summer of 1913 I ingested three *Cysticercus pisiformis* collected from a freshly killed rabbit. I did not ingest any of the cyst fluid and had no discomfort. There have been no indications of tapeworm development.

In view of the fact that ingestion of *Cysticercus pisiformis* by four persons has not resulted in tapeworm development in any case, and that Vital's and Cauvet's records show obvious evidence that there were no grounds for Vital's statement, it seems evident that his record of *T. pisiformis* should be distinctly characterized as erroneous.

Multiceps serialis has never been claimed as a parasite of man. Galli-Valerio (1909) states that he has eaten two larval scolices, and I recorded in 1910 the eating of three such scolices. No tapeworms developed in either case, indicating that the parasite will never be found as an accidental parasite of man. In passing, it may be said that on the face of it there would seem to be more likelihood of this parasite, which is frequently imbedded in the connective tissues in the edible musculature of the rabbit, functioning as a parasite of man than there is in the case of *T. pisiformis* where the fully developed larva is found among the inedible viscera.

Taenia teniaeformis has never been recorded as a parasite of man, but Krabbe (1880) has called attention to the fact that in Jutland, mice are sometimes chopped up, spread on bread and eaten raw as a folk remedy for retention of urine, and has suggested that this might lead to infestation with the adult worm. Moniez (1896) states that he has fed *Cysticercus fasciolaris* to his two volunteer subjects noted above without producing the adult tapeworm.

Taenia krabbei is another carnivore tapeworm that has not been reported from man, though its occurrence in the edible meat of an important food animal would indicate the likelihood of its occurring in man. However, Moniez (1896) states that his volunteers have ingested the larvae of this tapeworm without results.

Taenia tenella was surmised by Cobbold to be a human tapeworm arising from *Cysticercus ovis* in the meat of sheep. Railliet (1885) notes that Chatin has on several occasions ingested *Cysticercus ovis* without giving rise to a tapeworm, and Ransom (1913) states that he has ingested ten of these larvae without result. The tapeworm produced by feeding *Cysticercus ovis* to dogs was considered by Chatin to be *T. hydatigena,* but Ransom (1913) has shown that it is a distinct species of carnivore tapeworm, *Taenia ovis*. The fact that *Taenia ovis* and *Taenia krabbei,* both with larvae situated in the edible musculature of important food animals, seem incapable of developing in man, is a

further argument against the likelihood of such a tapeworm as *T. pisiformis*, with larvae in the inedible viscera, developing to an adult tapeworm in man.

Taenia hydatigena and *Multiceps multiceps* have never been reported as intestinal parasites of man. This is not surprising, in view of the size of the larvae and site of infection for the larvae. It is further likely that if they were present the former would be taken for *T. solium* and the latter for the more common *T. pisiformis*. I have found no records of the ingestion of the larvae by man, but Stiles (1898) states of the larvae of *T. hydatigena*, "Although several authors have attempted to infect themselves with tapeworms by swallowing this larvae, all such attempts have been negative."

The facts noted above indicate the correctness of the generally accepted view, that adult cestodes of the genus *Taenia* occurring in carnivores do not occur in man. The converse of this proposition is also true.

A PECULIAR MORPHOLOGIC DEVELOPMENT OF AN EGG OF THE GENUS TROPIDOCERCA AND ITS PROBABLE SIGNIFICANCE

Winthrop D. Foster

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The accompanying drawing represents the egg of a species of *Tropidocerca* from the proventriculus of an American woodcock (*Philohela minor*) shot at Bowie, Md., Nov. 11, 1912. A comparison of the specimens found, with the different species descriptions, shows that the specimens belong in all probability to an undescribed species, but as no male worms were recovered it is considered inadvisable to publish a specific description until more material can be collected.

The drawing is presented to show the peculiar filiform appendages projecting from either pole, a feature not only undescribed in any of the species of this genus, but, as far as the writer is aware, unique in the literature of nematodes.* The appendages consist of a cluster of seventeen to twenty-three filaments at either pole of the egg. Most of these are not over half the length of the egg, but one or two at either pole are over twice as long.

One of the distinguishing characteristics of the trematode family, Notocotylidae, is the fact that the eggs are provided with a single long filament at either pole. To judge from the drawing of an egg of *Notocotyle quinqueseriale* Barker and Laughlin (1911), these filaments are simple prolongations of the chitinous shell. This is certainly the case in the genus *Microcotyle*, certain species of which have similar filaments, as MacCallum (1913) has seen these filaments in the process of formation from the shell. The filaments of *Tropidocerca* are, however, apparently of a different nature, and are undoubtedly formed in a different manner.

In examining a number of *Tropidocerca* eggs removed from a ruptured uterus, it was observed that only those eggs which contained fully developed embryos and which were in a position to pass through the vagina, were equipped with these filaments. Less mature eggs had perfectly smooth shells, as with most nematodes. It is obvious, there-

* Since this note was submitted for publication an article has appeared by Seurat (Compt. rend. Soc. de Biol. v. 76, 15 mai 1914) describing *Tropidocerca nouvelli* n. sp. which is characterized by similar appendages attached to the poles of the embryonated eggs. Seurat points out that similar appendages were observed by Kölliker on the eggs of *Ascaris dentata*, and by Lieberkühn in his *Tropidocerca fissispina*. Lieberkühn, failing to find this feature on all the eggs, considered it merely as an individual anomaly.

fore, that the filaments are not simple prolongations of the chitinous shell, but are added after the egg-shell is complete. This is also apparent from the figure in which the egg-shell is seen to form a complete ellipse, to the surface of which the filaments are attached.

Leuckart (1867) has shown that the albuminous covering of the eggs of *Ascaris lumbricoides* is deposited after the chitinous shell is complete, and the mamillations of this covering and the fact that it appears only on completely formed eggs suggest an analogy with these filiform appendages.

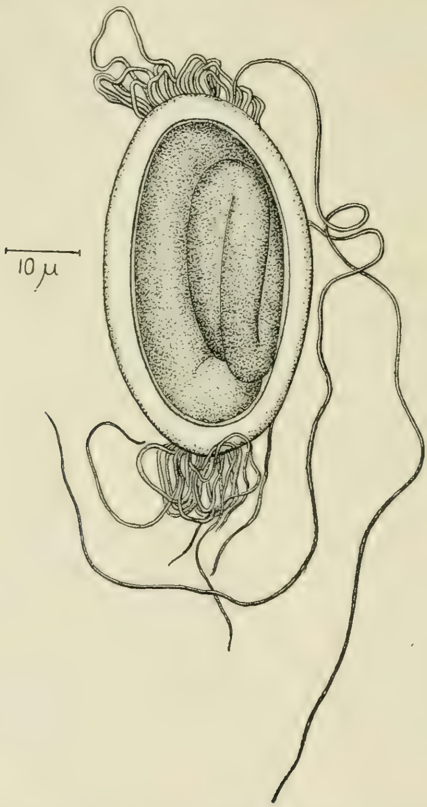

Fig. 1.—Egg of *Tropidocerca sp.*, showing masses of filaments projecting from either pole.

In one of the specimens of *Tropidecerca sp.* examined by the writer, which had been pressed under a cover-glass, a number of eggs attached at their poles by the entangling of their filaments, were seen to be forced through a rupture in the uterus. It would appear, therefore, that these filaments are for the purpose of causing a number of eggs to cling together, thereby increasing the chances of infestation in the host. It is suggested by von Linstow (1879) that the eggs of the

genus *Tropidocerca* require an intermediate host. He bases his opinion on the relative thickness of the shell, the great number of eggs in a single female and their similarity to the eggs of the genus *Filaria*. If the life cycle is indirect, it would appear decidedly advantageous for the parasite that the intermediate host should be heavily parasitized, since in this way the handicap of an indirect life cycle would be lessened.

The eggs of different groups of parasites are not infrequently provided with means for furthering their life cycle. These devices are either to enable the egg to remain on its host in the case of ectoparasites, or to insure a heavy infestation of the host in the case of endoparasites. Among the former may be mentioned the long filamentous hooklets which enable the egg of the genus *Menopon* to fasten in the feathers of the host, and the method of glueing the eggs of *Haematopinus* to the hairs of its host. As a method of insuring a heavy infestation of the host in endoparasites may be mentioned the egg sacs of the cestode genus *Davainea* and the strings of eggs oviposted by *Strongyloides ovocinctus*. In this case, as described by Ransom (1911), "the eggs passing out of the vulva lodge beneath an outer cuticular layer, which, when finally shed by the worm, is transformed into elongated egg-sacs, each containing from half a dozen to fifty or more eggs." A still closer analogy to the filamentous appendages shown is seen in the mamillated albuminous covering of *Ascaris lumbricoides*, which, as Blanchard (1888) has observed, sometimes causes the eggs to adhere to one another at the poles, exactly as was observed in the case of *Tropidocerca*.

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THE ACTION OF ARSENICAL DIPS IN PREVENTING TICK INFESTATION

H. W. Graybill
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During the summer of 1912 the writer conducted experiments relating to the action of arsenical dips in preventing cattle from becoming infested with cattle ticks. The data obtained at that time were published in Bulletin 167 of the Bureau of Animal Industry. The results showed that cattle dipped in an arsenical dip are protected for two full days from becoming infested with seed ticks, but not for five days. During the past summer experiments were undertaken to determine what protection, if any, such dipping offers for a period of three and of four days, and whether there is any mortality of ticks applied to and maturing on immune animals that have been subjected to a number of dippings at intervals of one and two weeks.

The dip employed was the usual arsenical dip used in this country in the tick eradication work in the South, containing 8 pounds of white arsenic to 500 gallons of dip, with the exception that the pine tar was omitted in order to exclude the possibility of the tar playing any part in the results by exercising a repellent action on the ticks.

Two experiments were carried out. In Experiment No. 1 cattle were exposed to infestation on the third and fourth days after dipping. Six calves non-immune to Texas fever were divided into three lots of two each. In the case of Lot No. 1 seed ticks were applied three days after dipping, and in the case of Lot No. 2 four days after dipping. Lot No. 3 was not dipped and served as a control. Seed ticks were applied to this lot on the same date as to Lot No. 1. After the seed ticks were applied the different lots were placed in separate paddocks which they occupied until the close of the experiment.

As a result of this experiment it was determined that animals dipped once in an arsenical dip containing sodium arsenite equivalent to 0.1863 per cent. As_2O_3 were not protected from infestation when ticks were applied three days (Lot No. 1) and four days (Lot No. 2) after dipping. It was found, however, that the infestation of the dipped animals was light, whereas that of the two controls was heavy. It would therefore appear that dipping reduced markedly the degree of infestation. Since practically no dead nymphs were observed on the animals, it is evident that the lighter infestation of the dipped animals must have been brought about by an action on the larval stage,

which, as demonstrated in last year's experiments (Bulletin 157, Bureau of Animal Industry), is in the nature of a destructive action.

This experiment completes the work of last year, which demonstrated that cattle dipped in an arsenical dip such as used in this experiment are protected for two days, but not for five days, from infestation. The present experiment shows that the toxic action of the arsenic on and in the skin of dipped cattle is still effective to a certain degree on the third and the fourth day after dipping.

In Experiment No. 2 ticks were applied to animals five days after the last of four dippings at intervals of two weeks and of one week. This experiment was conducted primarily for the purpose of determining whether ticks that mature on animals that have been regularly dipped show any mortality after dropping off, due to arsenic absorbed from the skin of the animal.

Six immune calves divided into three lots of two each were used. Lot No. 1 was dipped four times at intervals of two weeks, Lot No. 2 four times at intervals of one week and Lot No. 3 remained undipped as a control. All the calves had ticks applied to them five days after the last dipping.

In the case of Lot No. 1, one of the calves acquired a heavy, the other a light infestation; whereas, in Lot No. 2, in which the animals were dipped at intervals but half as long, the animals became only very lightly infested. In the control (Lot No. 3) both animals became heavily infested with ticks. It is therefore seen that dipping animals four times at intervals of one and of two weeks will not protect them from becoming infested when ticks are applied five days after the last dipping. The degree of infestation did not appear to be reduced in the case of the animals dipped at intervals of two weeks (Lot No. 1), but in the case of those dipped at intervals of one week the infestation was reduced to a very marked extent. It is therefore seen that when the interval between dippings is two weeks there is no increment in the toxicity of the skin of cattle, whereas when the interval is one week there is an accumulation of arsenic from previous dippings sufficient to destroy some ticks and thus reduce the degree of infestation.

Large numbers of engorged ticks were collected from the dipped and the control animals and kept in the laboratory in Petri dishes. Observations were made on these with regard to mortality, oviposition, number of eggs deposited and the percentage of eggs hatching. It was found by comparison with the controls that the ticks from the dipped animals manifested no abnormality. In other words, it may be said that ticks placed on animals five days after the last of four dippings, at intervals of one week and of two weeks, and permitted to engorge show no indication of arsenical poisoning.

EORHYNCHUS: A PROPOSED NEW NAME FOR NEORHYNCHUS HAMANN PREOCCUPIED *

H. J. Van Cleave

The genus *Neorhynchus* was founded in 1892 by Hamann to include *Echinorhynchus rutili* Müller and *Echinorhynchus agilis* Rudolphi. Practically all investigators dealing with the Acanthocephala since that date have accepted this generic name. Recently attention has been called to the fact that the name *Neorhynchus* is preoccupied. Sclater, in 1869, and, again, Milne Edwards, in 1879, employed it for other groups. In accordance with the laws of nomenclature, it then becomes necessary to reject the name *Neorhynchus* as applied to Hamann's genus. I propose the name *Eorhynchus* to designate these forms. While all other investigators dealing with this genus have been limited to a study of the two original species, it has been my good fortune to include five additional species in a comparative study, the results of which have led me to a restatement of its essential characteristics. As pointed out in an earlier paper (1913), I consider the following points as diagnostic for this genus of *Acanthocephala:*

1. Six giant nuclei in the subcuticula arranged, normally, five in the middorsal line of the body and one in the midventral line.
2. Two giant nuclei in one lemniscus and only one in the other.
3. Proboscis receptacle with but a single muscle layer in its wall.

In the light of this analysis, the contentions of de Marval (1904: 582) and of Monticelli (1905: 217), that *Apororhynchus hemignathi* Shipley should be included in this genus are based on an inadequate understanding of its natural limits.

Shipley, in his description of *A. hemignathi* (1896: 210), wrote: "As in *Neorhynchus,* the number of nuclei is very small, some twelve to twenty seem to suffice for the whole subcuticle, and perhaps two to four for each lemniscus. The nuclei are scattered about in a most irregular fashion. . . ."

I have shown (1913) that not alone the *presence* of giant nuclei, but more strikingly their *number* and *arrangement* furnish a sure criterion for the determination of members of this genus. Shipley's genus *Apororhynchus,* because of its radical departure from the typical structure of the *Eorhynchi,* cannot be included within the genus *Eorhynchus.* The valid species of this genus are, then, *Eo. rutili* (Müller

* Contributions from the Zoological Laboratory of the University of Illinois, under the direction of Henry B. Ward, No. 32.

1784), *Eo. agilis* (Rudolphi 1819), *Eo. emydis* (Leidy 1852), *Eo. gracilisentis* (Van Cleave 1913), *Eo. longirostris* (Van Cleave 1913), *Eo. cylindratus* (Van Cleave 1913) and *Eo. tenellus* (Van Cleave 1913).

Hamann (1892) also created the family Neorhynchidae for the single genus *Neorhynchus*. Porta (1907:409) accepted Hamann's revision of the Acanthocephala only in part, recognizing but two families, Echinorhynchidae and Gigantorhynchidae, and included *Neorhynchus* under the former. The characteristics already listed as diagnostic for the genus *Eorhynchus*, together with the complete fusion of the cement glands, are such essential features that the inclusion of *Eorhynchus* in the same family with *Echinorhynchus* would so distort our conception of the family Echinorhynchidae that it would cease to be a natural division of the Acanthocephala, and would become a purely artificial assemblage. In view of these facts I consider that the evidence fully justifies the retention of the family rank originally attributed to these forms for which the family name now becomes Eorhynchidae.

The writer's extensive studies on the cytology of the Eorhynchidae furnish conclusive evidence in support of the foregoing arguments. These studies in detail appear in the June number of the *Journal of Morphology*.

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SOCIETY PROCEEDINGS

THE HELMINTHOLOGICAL SOCIETY OF WASHINGTON

The sixteenth regular meeting of the society was held at the residence of Dr. Ransom, Dec. 18, 1913, Dr. Ransom acting as host and Dr. Graybill as chairman.

A letter from Mrs. Elise Huber, announcing the death of her husband, Dr. J. Ch. Huber, a foreign corresponding member of the society, was read and the secretary instructed to reply, conveying the society's regrets.

The following papers were read: Notes on Sarcosporidia, by Mr. Crawley; The Ingestion by Man of Cysticerci of Carnivore Tapeworms, by Mr. Hall; Variations in the Eggs of *Ascaris,* by Mr. Foster; The Effect of Refrigeration on Trichina, by Dr. Ransom; and The Effect of Arsenical Dips on Ticks, by Dr. Graybill.

MAURICE C. HALL, *Secretary.*

The seventeenth regular meeting of the society was held at the residence of Mr. Hall, Jan. 22, 1914, Mr. Hall acting as host and Dr. Ransom as chairman.

Mr. Crawley gave a review of Calkins' paper on the cultivation of amoebae.

Mr. Foster exhibited some drawings of the eggs of *Tropisurus* and presented a note in regard to them.

Dr. Hassall called attention to the index of Castellani and Chalmers latest edition of Tropical Medicine, noting the fact that it had been very poorly constructed and introduced a number of synonyms.

Dr. Cobb presented a note on the crystalline inclusions in the intestinal cells of *Rhabditis* and other free-living nematodes, and demonstrated these inclusions.

Mr. Hall presented a note proposing a new genus for *Distoma tricolor* Stiles and Hassall 1894.

Dr. Ransom presented a paper on the refrigeration of beef infested with beef measles.

MAURICE C. HALL, *Secretary.*

The eighteenth regular meeting of the society was held at the residence of Mr. Crawley, March 12, 1914, Mr. Crawley acting as host and Dr. Graybill as chairman.

Mr. Hall presented a paper entitled An Unusual Case of Fatal Poisoning from the Administration of Male Fern as a Vermifuge.

Mr. Crawley presented a paper entitled Early Stages in the Life History of *Sarcocystis muris.*

MAURICE C. HALL, *Secretary.*

The nineteenth regular meeting of the society was held at the residence of Mr. Foster, April 14, 1914, Mr. Foster acting as host and Dr. Cobb as chairman. Dr. Georgina Sweet and Miss Frieda Cobb were the guests of the society.

Dr. Ransom presented a paper entitled The Occurrence of a Fly Larva in the Heart of a Hog.

Mr. Hall presented a paper entitled A New Genus of Discodrilids, with a Key to the North American Species.

Mr. Foster presented a paper entitled The Specific Characteristics of *Metastrongylus apri* and *M. brevivaginatus.*

Dr. Cobb exhibited and discussed his recent publication entitled Antarctic Marine Free-Living Nematodes of the Shackleton Expedition; Contributions to a science of nematology. This paper is published by the author as a tribute to Shackleton. The excellent illustrations are by Miss Frieda Cobb, a limited number of copies being hand colored, and the very striking cover-design is by Mr. Chambers. The publication bears the stamp of that individuality which is so characteristic of Dr. Cobb's papers.

MAURICE C. HALL, *Secretary.*

The twentieth regular meeting of the society was held at the residence of Dr. Cobb, May 12, 1914, Dr. Cobb acting as host and Dr. Ransom as chairman.

Mr. Hall presented a paper entitled The Superfamilies of the Parasitic Nematodes.

Mr. Foster presented a triradiate specimen of *Taenia pisiformis* and some cross sections of the worm, which was collected from a dog imported from Europe and held in quarantine at Athenia, N. J. The specimen is therefore European and not American.

Dr. Ransom presented a note on the relation of parasitic worms, especially nematodes, to cancer, and called attention to his description of *Agamonematodum gaylordi,* recently published in a Fisheries Bulletin entitled Carcinoma of the Thyroid in the Salmonoid Fishes, by Gaylord and Marsh. There seems to be very good evidence that the nematode may act at times as an inoculating agent in the production of carcinoma.

Dr. Cobb exhibited to the society specimens representing twenty-seven new genera of free-living nematodes and pointed out various peculiarities in connection with the annulation, mouth parts, spicules, spermatozoa and nutritional granules.

MAURICE C. HALL, *Secretary.*

NOTES

HELMINTHOLOGIC INVESTIGATIONS

The departure of the expedition, under the direction of Dr. R. T. Leiper, Helminthologist of the London School of Tropical Medicine, to the Eastern Tropics, is an event which must prove of considerable scientific importance. Accompanying Dr. Leiper is a medical officer seconded by the admiralty, Surgeon E. L. Atkinson, R.N., who, since his return from the Scott Antarctic Expedition, has been working at the London School of Tropical Medicine on pathologic specimens he brought back from South Polar regions. The personnel of the expedition is further perfected by the presence of a zoologist, Mr. A. Cherry-Garrard, who served as assistant zoologist in the late Antarctic Expedition. The funds necessary for the investigation have been found partly from the bequest of the late Lord Wandsworth to, and now under the control of, the London School of Tropical Medicine, and partly they have been contributed to by the Tropical Disease Research Fund of the Colonial Office.

The primary object of the expedition is to ascertain the mode of spread of the trematode diseases of man.

Facilities for investigation have been afforded by several countries, and in Sumatra the United States Rubber Company have specially invited the expeditionary party to study the helminths as they affect the workmen on their rubber estates.

In a previous leader in this journal we drew attention to the solidarity of scientific investigation, citing as an instance the bearing Arctic and Antarctic pathologic and zoologic findings had on our geographical knowledge of the spread of disease, and of the limitations or otherwise of pathologic germs by heat and cold. The association of experts with a first-hand knowledge of these subjects in the frigid zones is of particular interest on the occasion of this the most recent scientific expedition to the Tropics.

The intestinal parasites met with in man in the Tropics might well be termed legion, and no medical practitioner who deals with tropical ailments at home or abroad can afford to do aught as a first and stereotype item of practice but to administer an anthelmintic, or at least a simple purge, so as to ensure that there is no worm or its ova complicating the symptoms of any of the intestinal derangements that may come to him for treatment. How often even the most skilful doctor in the Tropics has had cause to repent the non-observance of this practical axiom. Intestinal fluxes ascribed to dysentery, acute, chronic or intermittent sometimes prove intractable to the customary remedies for dysenteric lesions, and the cause of the resistance to their action is not detected until the patient goes to another doctor, who, administering an anthelmintic, clears up the mystery, to the chagrin of the aforesaid and the loosening of the unflattering tongue of the sufferer. Apart, however, from the mere clinical aspect of the good this expedition may do, there are larger and more important factors to be considered, namely, the public health and the commercial points of view. These are intimately associated. The good health of the workers in a mine, on a rubber, tea or coffee plantation, or on any commercial undertaking where men are employed in large numbers, affects the commercial value of the undertaking they are engaged on to the extent that it may have to be abandoned by the capitalist owing to the monetary losses ill-health entails. Such a state of things affects the whole world by the fact that many necessary articles of food become dearer not only locally, but universally, and the tea, coffee, cocoa, sugar, rice, tapioca, sago, etc., of our ordinary diet is enhanced in price. Thirdly, the scientific advance likely to ensue from the expedition may be hoped to be great and lasting. The men engaged on it have a high scientific reputation and their work is sure to be sound and reliable. It is to be hoped that our knowledge of bilharziosis will be advanced, that ankylostomiasis will be rendered more capable of being controlled, and that the flora of the intestine generally will be placed on a surer footing than obtains at present.—*Journal of Tropical Medicine and Hygiene,* March 16, 1914.

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TICK PARALYSIS *

John L. Todd

(Communicated to the Royal Society of Canada, May 28, 1914.)

Although for many years it has been well known by physicians practicing in southern British Columbia that paralysis may appear in children who have been bitten by ticks, it is only a few months since accounts of such an affection as "tick paralysis" appeared in scientific publications (Todd, 1912, 1912a; Temple, 1912). Medicine owes a debt to these practitioners, Corsan, Henderson, Hall, Kingston, Morris, Rose, Shewan and Temple. Their observations have supplied the first records of paralysis produced in children by the bites of ticks.

The first accounts of the disease were merely short descriptions of the symptoms which had been observed by half a score of physicians in a series of more than twenty-five cases. The patients had been seen during a number of years — Temple saw his first case in 1898 — in various places in southern British Columbia and in the neighboring portions of the United States. All of the patients were children; there were, however, somewhat obscure accounts of instances in which symptoms, resembling those observed in children, had been seen in men who had been bitten by ticks. The history and symptoms were much alike in all of the cases. The usual story was that an active and apparently healthy child suddenly developed a paresis or paralysis of the legs; neither abnormal temperature nor any other symptom but paralysis was constant. After the tick was discovered and removed the symptoms disappeared within a few hours, with the possible exception of a more or less local reaction, often probably due to a secondary bacterial infection, at the site of the tick's bite. In some of the cases reported the tick was not removed; in them the paralysis progressively involved the whole body until reflexes and control of the sphincters were lost, and death ensued.

The symptoms of these cases suggest infantile paralysis (acute poliomyelitis); but they are probably to be distinguished from cases

* I wish to express my indebtedness to all those who have supplied me with the information and material which has made this paper possible; the names of most of them are mentioned in it.

of that disease by the invariably transitory nature of their paralyses. In no instance has "tick paralysis" left permanent disability. It seems impossible to explain these many cases of "tick paralysis" as mere coincidences, in which tick infection has been fortuitously associated with sporadic attacks of a peculiarly mild form of acute poliomyelitis; none of the practitioners who saw these cases have recorded the contemporary existence of definite cases of acute poliomyelitis. Also, the symptoms of these cases of paralysis have little in common with the symptoms of the typhus-like "spotted fever," which is seen in persons bitten by ticks (*Dermacentor venustus*) in some parts of Montana. For these reasons it seems certain that a form of paralysis associated with the bites of ticks occurs in children in western North America and that the infection can be identified with no known disease. Similar cases from Wyoming and Montana have been reported (Bishopp and King, 1913). More recently very similar histories of instances in which paralysis has followed the bites of ticks (probably *Ixodes ricinus* or *I. holocyclus*) have been reported from Australia (Eaton, 1913).

Hadwen (1913) describes the occurrence of paralysis in sheep, which have been bitten by ticks, in British Columbia. He and Nuttall (1914) give references to publications which describe the existence of a paralysis caused by ticks (of a species, *I. pilosus,* other than that which exists in British Columbia) in South African sheep. Hadwen succeeded in producing paralysis in a lamb on which a tick (*D. venustus*) had, experimentally, been allowed to feed. He, with Nuttall (Hadwen and Nuttall, 1913), was successful in producing the same symptoms in a dog. A very complete bibliography of the effects of tick bite can be reached by a search through the papers referred to in this communication. Hadwen, especially, gives a good list of articles on the bites of ticks.

Since the observations contained in the publications mentioned above were published, the cases recorded below have been reported.

Dr. W. J. Knox, Kelowna, B. C., records two cases.

April 23, 1913, a boy of 4 years had pronounced flaccid paralysis from the hips down. He could not stand; his arms were weak; there was hyperesthesia; the pupils were normal; the temperature was 100 F.; the pulse was 112. The first symptom had been a little stiffness of the legs twenty-four hours previously; it progressed until in twelve hours walking was extremely difficult. A tick was found in the left axilla. It was removed by snipping it out with the tissue about its head; the wound was dressed antiseptically. A purgative was given to the child and, under slight stimulation, the pulse quickly became full and steady. In twenty-four hours the child could move his limbs fairly well, and in forty-eight hours he was apparently as well as ever.

April 21, 1914, a girl of 3 years had slight paralysis of the right leg. The temperature was normal. Her condition was said to be better than it had been two hours previously; so rest and a purgative were prescribed. Twelve hours later the child was stuporous. Her legs and arms were entirely par-

alyzed; she could neither articulate nor swallow, and seemed to be sinking very rapidly. The pulse was 130, small and weak. The temperature was 102 F. No tick was found on the child's body, but the hair was clipped short and a small wood tick was found at the base of the skull. It was removed by snipping it out with the tissue surrounding its head. The wound was dressed antiseptically and purgatives and stimulants were given; in six hours the child's temperature was 99.4 F., her pulse 100 and regular and she was conscious and asking for water. In twelve hours she could move her limbs and in five days was running about as well as ever.

Dr. Knox also reports a case of quite another type in an adult.

April 27, 1914, a man of 28 years was seen. He gave a history of having pulled off the body of a tick, leaving the head behind, from the calf of his left leg. At the site of the bite was a large bluish-black area surrounded by much induration. The patient's body was covered with a spotted erythema. He felt very ill, and complained of vertigo and of pains in the back and in the legs. His pulse was 108, his temperature 102.5 F. Sensation was lost in the right leg from 6 inches below the hip-joint; the left leg was paralyzed. The head of the tick was excised and the wound dressed antiseptically. A purgative was given and in twelve hours the temperature had dropped to 99.6 F. and the pulse to 86. In thirty hours the temperature was normal, and the rash and pain were gone; in four days the patient, being well, was discharged.

Dr. Knox records an instance in which a very thin colt, so weak that it could not stand, was covered with ticks; the ticks were removed and within a few days the colt was able to walk and gradually regained its health. (It is possible that this was nothing more than a case of severe "tick worry.")

Dr. Elmer Fessler, St. Regis, Montana, records two cases.

On the morning of May 19, 1914, a 2-year-old girl was found to be unable to walk or stand, although she had slept well and had been quite well on the previous day. She tried to walk several times during the day but she was unable to do so. When the physician first saw her, on the morning of the twentieth, her temperature was 96.5 F., her pulse 120 and her respiration was normal. She could move her legs, but she could not stand, and the leg reflexes were gone. There was considerable loss of function of the arms. The mother said more than on the previous day. No urine had been passed for twenty-four hours. Although the child was somewhat peevish, she took her food as usual. Two ticks (*Dermacentor venustus*) were removed from the nape of the neck; one was a half-engorged female, the other a male. The child was given cathartics. In six hours her hands were moved less clumsily and a little later she tried, unsuccessfully, to stand. At 9 the next morning she could walk and by noon was running about as usual. She has been quite well ever since.

In 1905 a girl of 5 years was seen who was said to have been unable to walk for forty-eight hours. She could not move her legs which were without reflexes. She could move her arms clumsily, but could hold nothing in her hands. A large tick was removed from the base of the skull and on the following day she seemed to be quite well, save for a slight weakness that persisted for some days.

Dr. A. W. Kenning, who practiced in Rossland, southern British Columbia, for sixteen years, mentions two cases.

One, the only fatal case, which he saw, was in a girl of 8. She had general paralysis and when the tick was found on her arm, she was comatose with a rapid pulse and high temperature. The other case was a child of 6 who had general paralysis; the whole body was involved. On removing the tick from the child's head, she recovered as was usual in such cases.

Dr. G. S. Gordon, Vancouver, B. C., has records of one case.

In 1904 (?) a girl of 5 years was seen. The child came of neurotic stock; she seemed well in every particular save that, though she could move her arms and legs while sitting on the floor, she could not walk nor put one leg before the other when she was supported in the erect position. A second practitioner, whose opinion was asked, told the parents to look for "wood ticks." One was found and on its removal the symptoms disappeared.

Dr. R. W. Irving, Kamloops, B. C., records a case in a child.

May 1, 1912, a boy of 8 years was seen. He complained of numbness in his legs and was unable to stand. He seemed rather sleepy and dull; but otherwise was healthy, save that he could only move his legs in an ataxic manner while lying in bed and that at times his arms seemed to become weak. The special senses were not affected nor were the cranial nerves involved. The knee-jerks were not obtainable. There was no ankle clonus, nor Babinski's sign. The sphincters were under control and there were no areas of anesthesia or hyperesthesia. The pulse was normal and the temperature was 99.2 F. A tick was found at the base of the skull and it was removed. Under rest and catharsis the boy, in three or four days, became perfectly well.

Dr. Irving, with Dr. Murphy, saw a case in which definite nervous symptoms in an adult were associated with the presence of a tick.

A normal, well-nourished male of 40 years complained that four days previously he found it difficult to speak and that he was awkward in his movements. He had been perfectly well and said that he had felt as though he were "partially drunk." A day later he fell on attempting to arise in the morning and was unable to balance himself in any way. When the patient was seen there were few constitutional symptoms and his only other complaint was that he felt "a bit seedy." On examination his hands and arms were found to be weak and incoordination was definitely present. The knee-jerks were absent; there was no ankle clonus, Babinski's sign, area of anesthesia or hyperesthesia, and no involvement of cranial nerves nor loss of sphincter control. A tick was found on the upper part of the back and removed. The symptoms commenced to disappear within twenty hours. In three days the man was as well as ever, and in three days more he was married.

These and other cases add a little to the first descriptions of the affection; they show that an elevated temperature, a rapid pulse and respiration and other constitutional conditions may frequently be symptoms. It also seems probable that nervous symptoms may supervene in adults who have been bitten by ticks. Convulsions, sudden stupidity and clumsiness are mentioned as symptoms that may follow tick bite. One physician asserts that in southern British Columbia practitioners, who have been in the country for long, always look for ticks on a child who has a convulsion. One or two physicians mention cases which suggest that spotted fever may not be entirely confined to Montana. There are many records of ulcers and other inflammatory lesions at the site of ticks' bites. Sometimes these lesions are said to be suggestively obstinate to ordinary treatment.

The experiments recorded below were made in the hope of producing, under experimental conditions, paralysis in laboratory animals, by the bites of ticks.

The way in which the experiments were done was practically identical in each instance. The animals, together with control animals, were well cared for. The lambs, when the experiments commenced, were from 4 to 6 weeks old; they were kept in pens with their mothers. The puppies were about the same age; they were kept in individual cages and fed on milk. The ticks were attached either to the nape of the neck or to the loins as is stated. The hair was removed either by slipping and shaving or by epilating powder. The ticks were then placed on the skin beneath a finely perforated porcelain filter cone, which measured about 1 inch in diameter at the base and 1 inch in height. The cone was fastened to the animal by an ample bandage of adhesive plaster, firmly stitched in position. As a rule, this method of attaching the ticks was satisfactory. In only one or two instances did the ticks find their way beneath the edge of the cone and become lost or fixed to the plaster. Paralysis was produced in no experiment.

Monkey 1.—Aug. 16, 1912. Two ticks (*D. venustus* or *D. andersoni*), sent by Dr. J. B. McClintic, Victor, Mont., were placed on the nape of the neck of a large rhesus monkey; August 21, both ticks, each half engorged and firmly attached, were removed. August 24, three ticks, from the same source, were placed on the nape of the neck; August 31, two engorged ticks were removed; one tick had disappeared. November 18, four ticks, obtained by Dr. Lee Ganson of Odessa, Wash., from "jack rabbits," were placed on the nape of the neck of this monkey; November 30, during the night the monkey pulled off the bandage and destroyed the ticks.

Monkey 2.—Aug. 16, 1912, three ticks (*D. venustus* or *D. andersoni*), sent by Dr. J. B. McClintic, Victor, Mont., were placed on the nape of the neck of a small rhesus monkey; August 20, the half-engorged ticks were removed. August 24, two ticks, from the same source, were placed on the neck; August 30, one engorged tick was removed; the second was dead.

Monkey 3.—May 2, 1913, three ticks (not identified) were placed on the nape of the neck of a large rhesus monkey. One of these ticks was that which was removed from the little boy whose case is recorded above by Dr. Knox at Kelowna, B. C. The other two were sent by Dr. Boyce, from a horse, from the same place. May 26, the engorged ticks were removed.

Ten ticks, all of them very probably *D. venustus,* fed on one or the other of these three monkeys. Paralysis appeared in none of the three, although the child from which one of the ticks had been taken was paralyzed.

Lamb 1.—April 20, 1914, two ticks (*D. venustus*) from H. P. Wood, Esq., Florence, Mont., were placed on the neck of a lamb about 3 weeks old. The ticks were collected from cattle in a district where "spotted fever" exists. April 21, the lamb was obviously disinclined to move. April 22, the lamb died. A naked-eye examination at the autopsy revealed nothing beyond four or five superficial, almost petechial, pneumonic areas on the lungs. One of these was sectioned and the lung was found to be congested and collapsed, rather than pneumonic. The stomach and intestines were filled with normally digested food.

Lamb 2.—On April 20, 1914, three female ticks, two *D. venustus* and one *D albipictus,* collected by Seymour Hawden, D.V.Sci., from horses at Keremeos,

B. C., were placed on the neck of a lamb about 4 weeks old. April 30, the three ticks, none of them engorged, were removed. Four ticks, three male and one female *D. venustus*, sent by H. P. Wood, Esq. (see Lamb 1), were placed on the neck; May 9, the engorged female and three unfed male ticks were removed. May 28, an engorged female *D. venustus*, taken by Dr. Arthur from the skin of a bear, at Nelson, B. C., was placed on the neck; June 5, the tick was removed unfed. June 19 two ticks, *D. venustus*, sent by R. A. Cooley, Esq., Bozeman, Mont., were placed on the neck; June 24, both ticks were removed, unfed.

Lamb 3.—April 24, 1914, four ticks, from H. P. Wood, Esq., Florence, Mont., were placed on the neck; April 30, two of the ticks were lost and one dead, the remaining living tick was not engorged. Four other ticks, two male and two female *D. venustus*, from the same source, were placed on the lamb; May 9, one of the ticks was dead, the three living ones were removed, none were engorged. May 28, one female, *D. venustus*, partially engorged, from Dr. Arthur (see above) was placed on the neck; June 5, the tick was dead; and probably was never attached. June 19, two *D. venustus*, from Bozeman, Mont., were placed on the neck; June 24, one unfed tick was removed, one was missing. June 25, three *D. venustus*, two females and one male, from Bozeman, Mont., were placed on the neck; July 2, one engorged female and one attached male tick was removed.

Lamb 4.—April 24, 1914, one male and one female *D. venustus*, from Florence, Mont., were placed on the neck; April 30, ticks removed; both had attached; one was fully engorged. Four other ticks, one male and three females, from the above source, were placed on the loins; May 9, ticks removed; all had attached; three were engorged. May 28, three partially fed ticks, one male and two female *D. venustus*, from Dr. Arthur (see above) were placed on the neck; June 5, ticks removed; the two female ticks were engorged; the male was not. June 6, a half-engorged female *D. venustus* was placed on the neck. This tick was one of those removed from the case recorded above by Dr. Fessler. June 12, tick removed; probably had not attached. June 19, a male *D. venustus*, also from Dr. Fessler's case, previously fed on Puppy 1, was placed on the neck; June 24, tick dead. June 25, a male and a female *D. venustus* from Bozeman, Mont., were placed on neck; July 2, the engorged female and unfed male ticks were removed.

Lamb 5.—April 30, 1914, a tick (unidentified) from the case described above by Dr. Irving, was placed on the neck; May 9, tick dead; apparently had not attached. May 28, one male and two female *D. venustus* from Dr. Arthur (see above) were placed on the neck; June 5, ticks removed; two were engorged; one not. June 19, two ticks, *D. venustus*, from Bozeman, Mont., were placed on the neck; June 24, ticks removed, only one was half engorged. June 25, four ticks, two male and two female *D. venustus*, from Bozeman, Mont., were placed on the neck; July 2, one female was dead, the remainder being attached, were left in position; July 7, an engorged female and one dead and one still attached male were removed.

Lamb 6.—May 5, 1914, two female *D. venustus*, from Dr. Hawden (see above), were placed on the neck of this lamb; May 16, both ticks, attached but not engorged, were dead. May 28, one partially engorged female *D. venustus* from Dr. Arthur (see above), was placed on the neck; June 5, tick dead, probably had not attached. June 19, one male and one female *D. venustus*, from Bozeman, Mont., were placed on the neck; June 24, both ticks dead; one attached; neither engorged. June 25, one female and one male *D. venustus*, from Bozeman, Mont., were placed on the neck; July 2, male dead, female engorged.

Lamb 7.—May 9, 1914, a female *D. venustus*, obtained from surveyors by Dr. Arthur of Nelson, B. C., was placed on the neck of this lamb. May 16, tick removed, three-fourths engorged. May 28, two partially engorged female *D. venustus*, obtained from Dr. Arthur, at Nelson, B. C., from a bear skin, were

placed on the neck; June 5, both ticks dead, probably never attached. June 19, two ticks, *D. venustus*, from Bozeman, Mont., placed on the neck; June 24, ticks removed, both attached, one half engorged. June 25, two ticks, *D. venustus*, from Bozeman, Mont., were placed on the neck; July 2, one male tick and one attached female removed, both were unfed.

About twenty ticks, almost all of them adult male or female *D. venustus*, fed on one or the other of seven lambs. Six of the lambs remained in perfect health. One of them (Lamb 1) died on the second day after two ticks were placed on it; it is not probable that the ticks were the cause of death, since other ticks from the same source were harmless to similar animals.

Guinea-Pig 1.—May 6, 1914, a male and a female *D. venustus* sent by H. P. Wood, Esq., Florence, Mont., were placed on the loins; May 16, ticks removed, the female was partially engorged. June 3, dead; the guinea-pig had seemed to be quite well, and temperature was not abnormal until May 16, when daily observations were discontinued. At autopsy, there were no signs of irritation about tick bites; the cause of death was bronchopneumonia.

No sign of paralysis followed the feeding of a single tick on a guinea-pig.

Puppy 1.—June 6, 1914, a male *D. venustus*, sent by R. A. Cooley, Esq., Bozeman, Mont., was placed on the back of a puppy, about 6 weeks old. This tick was one of those taken by Dr. Fessler from the case recorded above by him; June 12, tick removed, unattached and unfed. June 19, two male *D. venustus*, from Bozeman, Mont., were placed on the back; June 24, two ticks removed, both unfed and dead. June 25, one male and one female *D. venustus*, from Bozeman, Mont., were placed on the loins; July 2, both ticks dead, neither fed.

Puppy 2.—June 19, 1914, two male *D. venustus*, from Bozeman, Mont., were placed on the loins of a puppy about 8 weeks old; June 24, both ticks removed, unfed and dead.

Puppy 3.—June 19, 1914, two female *D. venustus*, from Bozeman, Mont., were placed on the loins of a puppy about 8 weeks old; June 24, ticks removed, both engorged.

Paralysis did not appear in a puppy on which two ticks fed.

The ticks used in all of these experiments were identified with the assistance of the key published by Banks (1908). *Dermacentor venustus* and *D. albipictus* were the only ticks received from southern British Columbia, and of these the former was much the more common. In a personal letter, Hadwen wrote that it is difficult to get *D. venustus* to feed under laboratory conditions unless it has been recently collected; the diaries of the above experiments ratify his statement. The ticks used in these experiments were confined in Ehrlenmeyer flasks plugged with cotton wool, and were kept in a humid atmosphere at 25 C. Care was taken to give every tick every chance for feeding; several of the ticks used in these experiments had opportunities for feeding on two or more animals. These conditions seemed to agree with some females which laid many fertile eggs; but about half of the females laid only a few eggs and these infertile ones.

In the records of the tick-feeding experiments only those ticks which were definitely engorged are counted as having fed. It is unfortunate that their number is not larger and, especially, that the ticks which had been removed from paralyzed children would not all feed well on the experimental animals. Enough fed, however, to justify the statement that, under the conditions of these experiments, not every bite of a tick (*D. venustus* and *D. albipictus*) is able to cause paralysis in the laboratory animals employed.

It was thought that the paralysis produced by the bites of ticks in children might be caused by some toxin secreted by the ticks. Experiments were therefore designed to ascertain whether an extract capable of producing paralysis in laboratory animals could be obtained from the bodies of ticks.

Experiment 380.—About 4 c.cm. of larvae of "Texas fever ticks," (*Margaropus* sp.?), obtained from Washington, D. C., through the courtesy of the Bureau of Animal Industry, were dried for six weeks, and were then ground up in 50 c.cm. of a 4 per cent. solution of glycerin in distilled water. The resulting mixture was shaken for one and a half hours and then passed through a Buchner and a Berkefeld filter. The fluid so obtained was inoculated beneath the skin of the rump of two rats and two mice; one rat and one mouse received 2 c.cm., the other rat and mouse 1 c.cm. The two mice died within twenty-four hours; no cause of death was evident. The rat which received 1 c.cm. died ninety-six hours after inoculation; the cause of death was not evident. The second rat died two weeks after inoculation, from bronchopneumonia; neither it nor any of the animals had ever shown any sign of paralysis, or of suppuration at the site of inoculation.

Experiment 400.—Ten adult *Margaropus annulatus* and about 700 larvae, also obtained from Washington, D. C., were dried, ground up in glycerin and water, shaken and filtered in the same way as was done in Experiment 380. Four c.cm. of the filtrate was inoculated beneath the skin at the back of the neck, of two rats; one received 2 c.cm., the other 4 c.cm. Neither rat developed any sign of paralysis nor was there suppuration at the site of inoculation in either.

Experiment 531.—About 3.5 c.cm. of dried ticks of all ages and of both sexes were employed. Most of them were adults. With the exception of one or two *D. albipictus*, all were *D. venustus*. These ticks were those, or their progeny, which had been used in the feeding experiments described above. All were ground up in 50 c.cm. of a 4 per cent. solution of glycerin in distilled water, shaken for two and a half hours and then filtered through a Buchner and a Berkefeld filter. Respectively, 2 c.cm., 4 c.cm. and 5 c.cm. of the clear filtrate was inoculated under the skin of the rumps of three young white rats, weighing about 30 gm. each. Paralysis appeared in none of them, although as in the previous experiments, all showed some disinclination to move; probably because of the soreness at the site of inoculation. One rat died four days after the inoculation. There was no sign of suppuration at the wound, and the cause of death was not evident to naked-eye examination, at the autopsy.

Experiment 532.—Five male, eight female and about 1,500 larval ticks, all living *D. venustus*, which had been used, or were the progeny of those used, in the above feeding experiments, were ground up, shaken and filtered in the same way as in Experiment 531. Respectively, 2 c.cm., 4.5 c.cm. and 6 c.cm. of the clear filtrate obtained was inoculated beneath the skin over the rump

of three young rats, each weighing about 30 gm. All of the rats survived; in none did paralysis appear.

EXPERIMENTS 550-551.—Three boxes, each containing a female *D. venustus*, and young seed ticks from her, were obtained from the Bitter Root Valley through the courtesy of R. A. Cooley, Esq. In two of the boxes the females and many hundreds of seed ticks were dead; in the third box the female and seed ticks were living. All were ground up together in 50 c.cm. of normal saline solution, shaken for two hours and then passed through Buchner and Berkefeld filters. About two-thirds of the whole filtrate obtained was inoculated subcutaneously over the withers of a 4½-months old lamb; 3.5 c.cm. of the filtrate was inoculated subcutaneously over the rump of a young white rat. Paralysis was never observed in either of these animals.

It has been proved (Nuttall and Strickland, 1908) that ticks secrete an anticoagulin which prevents blood from clotting. Observations were, therefore, made to ascertain whether an anticoagulin existed in the filtrate of extracted ticks, which was inoculated into the animals used in Experiments 380, 400, 531 and 532. Blood from a healthy man was drawn up into capillary tubes, of about 1 mm. internal diameter, with one-third, occasionally one-fourth, of its volume of the filtrate to be tested. A control tube was made in every instance, in which a 4 per cent. solution of glycerin was substituted for the filtrate. The tubes were then kept at room temperature, and the time in which the blood of each coagulated was observed. The tick extract used in Experiments 380 and 400 seemed to have no definite power of preventing coagulation, since coagulation usually occurred in both tubes in the same length of time. The tick extracts used in Experiments 532 and 531 had a definite, though slight, power of preventing coagulation. That used in Experiment 532 was definitely more powerful than that used in Experiment 531; with it, coagulation had usually only commenced at the end of three minutes, while it was complete at the end of that time in the control tubes. It is possible that the lack of symptoms obtained by the inoculation of the filtrates, as well as the lack of coagulating power of the filtrates used in Experiments 380, 400 and 531, may be explained in part by the comparatively large quantity of diluent in which the ticks were extracted. It must also be remembered that only in Experiment 532 was the extract made from living ticks.

It can be concluded that an extract of ticks, prepared in the manner described, will not cause paralysis in rats even when it possesses slight power to prevent the coagulation of human blood.

SUMMARY

1. Previous publications have proved:

(*a*) That a paralysis in children may be associated with the bites of ticks in western North America and in Australia.

(*b*) That a paralysis of sheep has been associated with the bites of ticks in British Columbia and in South Africa.

(*c*) That the ticks associated with these affections are of more than one sort.

(*d*) That *Dermacentor venustus* has produced paralysis in lambs and in a puppy in experiments made under laboratory conditions.

(*e*) That the paralysis following tick-bite is probably an individual and novel condition.

2. The paralysis of children is not infrequently accompanied by elevation of temperature and by other constitutional symptoms; it is possible that symptoms resembling those observed in children sometimes may appear in adults who have been bitten by ticks.

3. Under experimental conditions by no means every tick bite produces paralysis in laboratory animals.

4. A weak extract of ticks will not cause paralysis when injected into white rats, even though it possesses definite power to prevent the coagulation of blood.

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LARVAL TREMATODES FROM NORTH AMERICAN FRESH-WATER SNAILS

PRELIMINARY REPORT *

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Almost nothing is known of the life histories of the trematodes of North America. Some progress has been made in the study of the adults, but as yet there are only a few scattered observations on larval stages. During the fall of 1913 the study of the larval trematodes from fresh-water snails was undertaken by the writer at the suggestion of Prof. Henry B. Ward, as an attempt to open up this undeveloped field. The snails studied, which were obtained from several sources, yielded a surprisingly large number of species of cercariae, belonging to a wide variety of trematode groups. Fourteen new cercariae with their sporocysts or rediae were studied in detail, especial attention being given to observations on the living animals. The complete results of this work, embodying a detailed discussion of anatomy, histology and relationships, will appear shortly. The present report contains some of the more interesting observations on the structure and activity of these forms.

In the grouping of the cercariae the classification of Lühe (1909: 173-210) has been followed in most instances. In those groups in which the structure of the cercaria corresponds fairly closely to that of the adult, as in the amphistomes and the echinostomes, this classification is very satisfactory, but in those divisions where larval adaptations dominate the structure and where little is known of further development, as, for example, in the Stylet cercariae or microcercous group, the arrangement is certainly to some extent purely artificial.

Of the fourteen cercariae studied, one is a monostome, two are amphistomes and the rest belong to five different subdivisions of the distomes.

MONOSTOME CERCARIAE

Rediae and cercariae of a monostome, which I propose to name *Cercaria urbanensis,* were found during December 1913, in the livers of 5 per cent. of the full-grown specimens of *Physa gyrina* Say, from a drainage ditch near Urbana, Ill. There were present in the infected livers immature and fully developed rediae and free cercariae in dif-

* Contributions from the Zoological Laboratory of the University of Illinois, under the direction of Henry B. Ward, No. 35.

ferent stages of development. No rediae were present in which other rediae were developing and no mature cercariae remained in the rediae.

When freed from the liver of the snail the redia of this species has considerable power of extension and contraction, the immature ones especially stretching out the anterior end and reaching in all directions. No locomotor appendages were present in any stage and no locomotion was noted. In shape they are elongate sacs, smallest at the anterior end and widest in front of the posterior extremity. The intestine is voluminous, having a diameter of from one-third to two-thirds the width of the body and reaching almost to the posterior extremity.

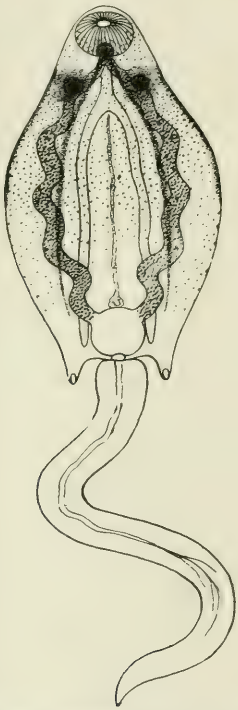

Fig. 1.—Mature *Cercaria urbanensis,* ventral view. Cystogenous glands not shown. X 140.

The methods of locomotion of *Cercaria urbanensis* (Fig. 1), either when swimming in open water or when creeping on a substratum, are very striking. The body when swimming is contracted into a round ball and the powerful tail is curled ventrad and lashes with great rapidity driving the animal with considerable speed through the water. In spite of the absence of a ventral sucker, the cercaria is able to creep by utilizing two projections which form the posterior lateral angles of the body. These projections, which are reinforced by cuticular struc-

tures, are thrust against the surface in a manner analogous to setae and aided by the oral sucker push the animal along. *Cercaria urbanensis* encysts in the open and the complete process of encystment was followed under the microscope.

The shape of *Cercaria urbanensis* is quite variable. An individual may contract until its length is 0.27 mm. and its width 0.20 mm., and it may extend itself to 0.54 mm. in length and 0.11 mm. in width. The tail changes its length from 0.20 mm. to 1.2 mm. The histological structure of this tail is very interesting on account of its adaptation for powerful movement. The structure of this cercaria agrees in a general way with that of a group of closely related monostomes of which *Cercaria imbricata* Looss (Looss, 1896: 192-197), and *Cercaria ephemera* Nitzch (Ssinitzin, 1905, Plate 4, Figs. 75 and 76), are examples. It differs from these forms in details of structure, such as the length of the intestine of the redia and the structure of the locomotor projections of the cercaria. *Cercaria hyalocauda* Haldeman, a monostome cercaria from North America, as described by Evarts (1880) is considerably larger than *Cercaria urbanensis.*

AMPHISTOME CERCARIAE

Amphistome cercariae are very easily recognized by the presence of the large acetabulum at the posterior end of the body. Although large numbers of adults of this type have been reported, but three cercariae are found in the literature, namely, the cercaria of *Diplodiscus subclavatus* (Goeze), best described by Looss (1892: 162-166); *Cercaria pigmentata* Sonsino, which was shown by Looss (1896: 185-191) to be the larval form of *Paramphistomum cervi* (Zeder), and the cercaria described by Looss (1896: 177-185) as the larval form of *Gastrodiscus aegyptiacus.* Of these cercariae that of *Paramphistomum cervi* belongs to the subfamily *Paramphistominae,* and the other two to the *Diplodiscinae.* My studies add to the second subfamily two cercariae, which differ from the known forms in details of structure both of the redia and cercaria.

These two cercariae were collected from specimens of *Planorbis trivolvis* Say, from three localities. Two snails out of eighteen of this species from Lawrence, Kan., and one from large numbers examined from around Urbana, Ill., contained the first of these forms, a large pigmented cercaria, to which the name *Cercaria inhabilis* is given. The second, a small unpigmented cercaria, *Cercaria diastropha,* was found in one of twenty specimens of *Planorbis trivolvis* from a small pond in the suburbs of Chicago. In all the infected snails adult and immature cercariae were found free in the livers, the mature forms being nearest the periphery, and the active rediae contained no fully developed cer-

cariae. There were no sporocysts present and no rediae in which rediae were developing.

The rediae of *Cercaria inhabilis* were all in about the same stage of development. When freed from the snail they were very mobile, extending and contracting and making some progress even on the smooth surface of a watch glass. There are present two pairs of locomotor appendages and the posterior extremity is attenuated and pointed. The pharynx is small in proportion to the size of the body and the intestine is voluminous and extends more than one-third of the distance from the anterior to the posterior ends.

Cercaria inhabilis (Fig. 2) swims sluggishly in open water. It contracts its body and lashes rapidly with its tail moving forward in an unwieldy irregular fashion. In fact, the body is too large in proportion to the size of the tail for rapid locomotion. On a substratum the cercaria extends and contracts its body, but is unable to creep with the aid of the suckers. It is the largest of the cercariae studied. In the different stages present the development of the pigmentation could be traced from little spots around the eyes until it spread through most of the body. Although cystogenous glands are highly developed, filling most of the body, none of the cercariae under observation were seen to encyst.

Cercaria diastropha (Fig. 3) resembles *Cercaria inhabilis* in general structure. It differs from this form in the size and shape of the body, the ratio in the size of the suckers and in the position of the acetabulum, in the amount of pigmentation, and in the anlage of the reproductive organs.

The redia of *Cercaria diastropha* is even more active than that of the former species, being able to move well with the aid of the two pairs of locomotor appendages and to stretch to five or six times its usual length. This mobility is correlated with extreme development of the circular muscles, which show clearly externally as annular rings.

The only adult trematode from North America which resembles these amphistome cercariae in structure is *Diplodiscus temporatus* Stafford. Cary (1909) described as belonging to the life history of this species sporocysts and rediae, both containing cercariae from *Goniobasis virginica* obtained near Princeton, N. J. In 1911 Cary kindly sent me some of the material used in the preparation of this paper, including specimens of *Diplodiscus temporatus* from his experimental tadpoles. A study of this material and a careful analysis of Cary's account shows that he has described as belonging to this species two entirely different types of cercariae, that is, a large gymnocephalous cercaria developing in rediae and a small xiphidiocercaria developing in sporocysts. Since in his infection experiments he used only the

larger species, he certainly can have no evidence that the smaller form has any connection with *Diplodiscus temporatus*. Therefore, Cary's whole discussion in the embryological part of the paper (1909: 617-647) which is based on the study of the sporocysts and the cercariae developing in them, cannot without further evidence be given a place

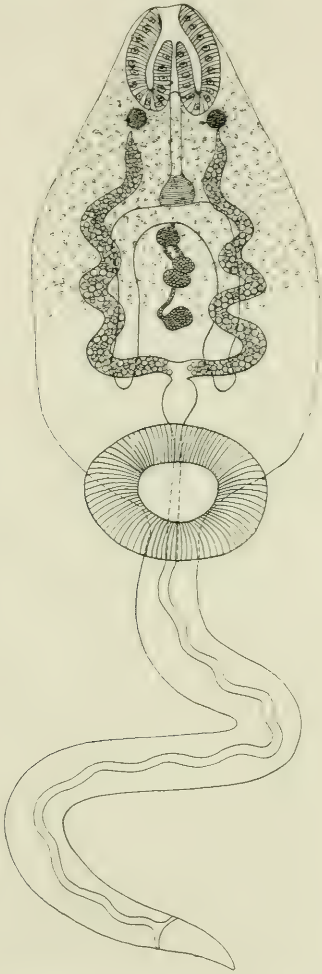

Fig. 2.—Mature *Cercaria inhabilis*, ventral view. Cystogenous glands not shown. X 88.

in the life history of *Diplodiscus temporatus*. However, it proves the thesis which Cary sets out to make that the embryo in the sporocyst develops from parthenogenetic eggs, and is therefore a very important contribution to trematode embryology. I am convinced that the larger form, which I shall call *Cercaria megalura*, is not the cercaria of

Diplodiscus temporatus, as Cary maintains, because it is so fundamentally different in structure from all known amphistome cercariae and from the adult of this species. Further, Cary's infection experiments are not sufficiently controlled to be conclusive and admit of an entirely different interpretation from the one he gives. To produce infection he puts the tadpoles into jars with snails which contain these cercariae and because the tadpoles were later found to be infected with

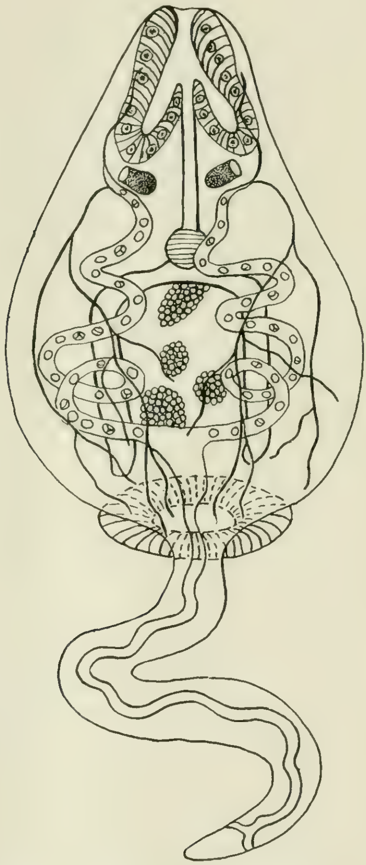

Fig. 3.—Mature *Cercaria diastropha,* ventral view. Cystogenous glands not shown. X 176.

Diplodiscus temporatus, he concluded that these trematodes had developed from cercariae in the snails. The first adults were found one week after the beginning of the experiments. These cercariae are so fundamentally different from the adults into which Cary supposed that they developed in one week's time, that I am convinced that he is in error in his conclusions and that the experimental tadpoles, in spite of

the checks which he used, were already infected with *Diplodiscus temporatus*. Lack of space admits in this report of only the bare outlines of the conclusions in this matter. A full discussion of the data and arguments which have led to the above conclusions will be published in the final paper.

The smaller of Cary's two species of cercariae I shall call *Cercaria caryi* (Fig. 4). Since it is very small and no living material is available for study, no extended description will be attempted. It evidently belongs to Lühe's group of Cercariae microcotylae under the Xiphidiocercariae. I was fortunate enough to obtain further material of *Cercaria megalura,* so that a detailed study was possible. Some facts concerning this form and certain corrections of Cary's description will be given here.

DISTOME CERCARIAE

The great bulk of known cercariae belong in this division. In my material were eleven distome cercariae representing five of the subgroups.

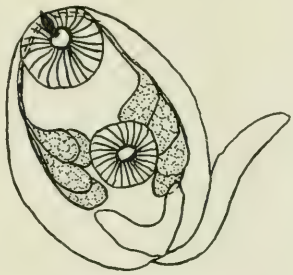

Fig. 4.—Mature *Cercaria caryi,* ventral view. From Cary's material. X 280.

Gymnocephalous Cercariae

Since beyond the fact that they develop in rediae the cercariae placed in this subdivision agree only in the absence of certain characters, it is probably an unnatural group. However, in the present state of our knowledge it is very convenient to retain it. From my material only *Cercaria megaluria,* wrongly described by Cary as the larva of *Diplodiscus temporatus,* belong here.

Rediae containing cercariae of this species were found in one from seventy-three specimens of *Pleurocera elevatum* Say, from the Sangamon River near Mahomet, Ill. This species, as Cary entirely failed to note, resembles very closely in both activity and structure *Cercaria distomatosa* Sonsino, best described by Looss (1896: 197-204). These two species differ in the size and the relations of the digestive system of the redia and in the size of the cercaria and in the relations of its excretory system. Since they differ very greatly from all others of the

gymnocephalous group, I propose to make them the basis of a subgroup, to which the name Megalurous cercariae may be given.

The rediae of *Cercaria megalura* are very active and the region back of the locomotor appendages on account of its mobility and attenuation resembles a tail. The anterior region of the body can be extended and contracted freely and with the aid of the locomotor appendages locomotion was possible. The intestine is very voluminous, being from one-third to two-thirds the diameter of the body and reaching almost to the posterior tip.

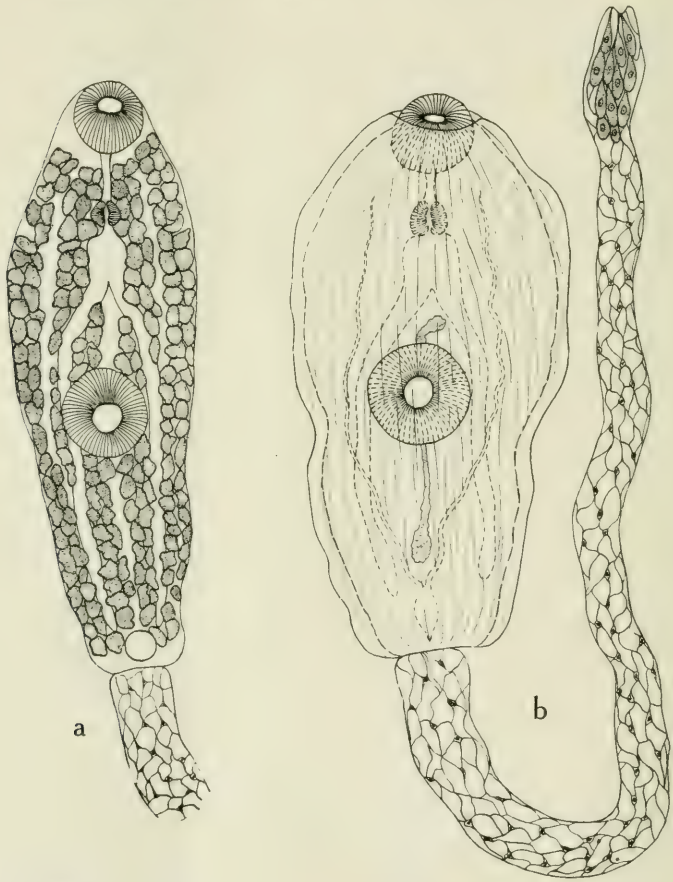

Fig. 5.—Mature *Cercaria megalura*, ventral view. (*a*) Before extrusion of cystogenous material. X 195. (*b*) After extrusion of cystogenous material. X 195.

Cercaria megalura (Fig. 5a) is unable to use its tail for swimming in open water, but on a surface creeps fairly rapidly with the aid of the suckers. At times the cercaria becomes attached by the tip of its tail which is furnished with an adhesive organ. It then becomes

extended to five or six times its usual length and is greatly attenuated. In this position it moves continually with a wriggling serpentine motion, which makes it resemble a tubificid worm. This activity probably aids in transfer to a secondary intermediate host. None of the cercariae were seen to encyst, although large numbers of them extruded cystogenous material in the form of a sort of open tube around the body (Fig. 5b).

The study of both Cary's and my own material of *Cercaria megalura* shows that he is in error in his description of the digestive system, the tail, and the anlage of the reproductive organs as is evident on comparison of Cary's Figure 6 of Plate 30 with Figures 5a and 5b of this paper.

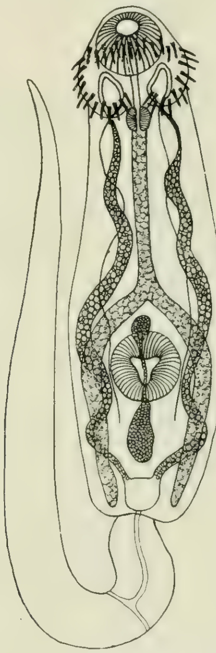

Fig. 6.—Mature *Cercaria trivolvis*, ventral view, cystogenous glands not shown. X 195.

Echinostome Cercariae

Cercariae belonging to the family Echinostomidae are very easily recognizable because of the presence as in the adult of the anterior collar and crown of spines. The structure of the excretory and digestive systems are also very characteristic for the whole group. The anterior crown of spines gives a very definite basis for comparison between larvae and adults, and many suggestions of life histories have been made on this character.

Two cercariae of this group were found in the material studied. In neither of them are the anterior spines like any of the known American adult echinostomes, and they differ in a number of points from any of the cercariae of this group described.

Rediae in which cercariae were developing, as well as encysted cercariae of the first of these species, for which the name *Cercaria trivolvis* is proposed, were found in several specimens of *Planorbis trivolvis* from Urbana, Ill. *Planorbis trivolvis* is able, then, to serve both as intermediate and secondary intermediate host for this trematode. The second echinostome species, *Cercaria rubra,* was found encysted in six out of thirty-six specimens of *Campeloma subsolidum* Anthony, from Hartford, Conn. The snail in this case is merely the secondary intermediate host.

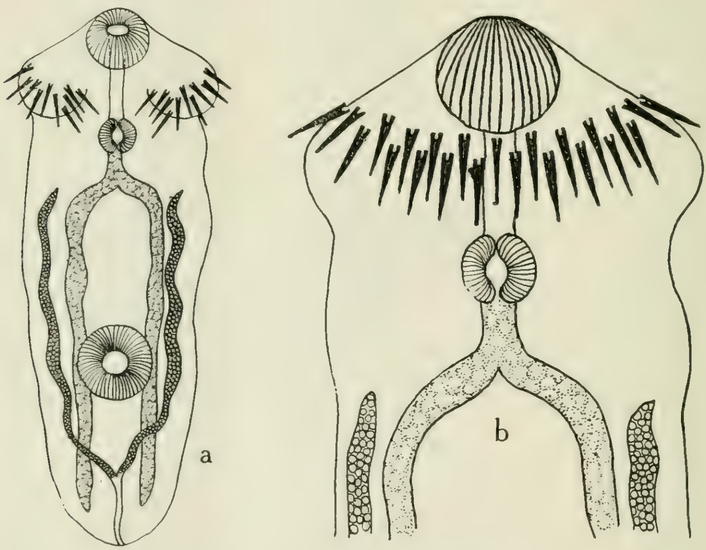

Fig. 7.—*Cercaria rubra.* (*a*) Freed from cyst, ventral view. X 195. (*b*) Anterior end of cercaria, dorsal view. X 390.

The rediae of *Cercaria trivolvis* are much like those described for other echinostomes, differing from them only in details of structure.

The cercaria (Fig. 6) of this species moves actively, both by swimming in open water and by creeping on a surface. The tail is powerful and extends when the animal is swimming to two or three times the length of the body. For the swimming movement the cercaria bends ventrad almost double, with the posterior half of the body above the anterior. The tail, which extends out beyond the anterior end, lashes vigorously and propels the animal rapidly. Of all the cercariae

observed only *Cercaria urbanensis* moved more rapidly than *Cercaria trivolvis.*

The crown of spines of *Cercaria trivolvis* consists of thirty-seven spines of equal size, arranged in two alternate rows which are broken in the middle of the ventral surface. The two or three nearest the midline on each side of the ventral surface point in. An idea of the general structure of this cercaria can be gained from the figure.

Cysts of *Cercaria rubra* were large and thick walled. The worm almost completely fills the cyst and moves only slightly. Worms were freed from the cysts and their structure studied (Fig. 7a and 7b). Most typical is the arrangement of the spines in the anterior collar. There are forty-three spines of uniform size arranged in two alternate rows. The four on each side nearest the midline of the ventral surface point inward.

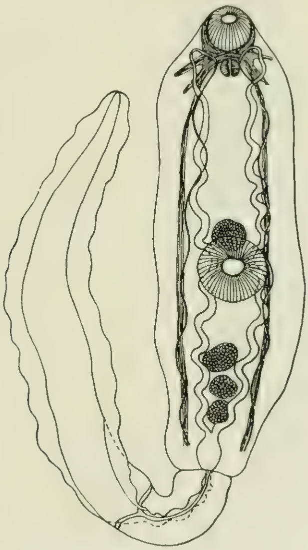

Fig. 8.—Mature *Cercaria reflexae,* ventral view. Cystogenous glands not shown. X 88.

As an appendix to the Echinostome cercariae I treat the following form: The livers of eight out of thirty-eight specimens of *Lymnaea reflexa* Say, from Chicago, contained rediae in which were developing a species of cercaria, for which the name *Cercaria reflexae* is proposed. Also in the body cavities of a number of the same snails were encysted cercariae of the same species.

Cercaria reflexae (Fig. 8) agrees with the echinostomes in the general structure of the redia, and in the method of locomotion and structure of the excretory and digestive systems of the cercaria. However,

it lacks entirely the anterior collar and crown of spines typical of the echinostomes. No record has been found of any species, either cercaria or adult, that corresponds in structure to this species.

Microcercous Cercariae

The group of microcercous cercariae includes a very heterogeneous collection. Some of them develop in rediae and some in sporocysts. Some have stumpy tails developed as suckers and some have merely blunted tails. Dollfus (1913) has already formed within this group a subdivision, the Cotylocercous cercariae, which contains a number of marine forms, centering around *Cercaria pachycerca* Diesing, with

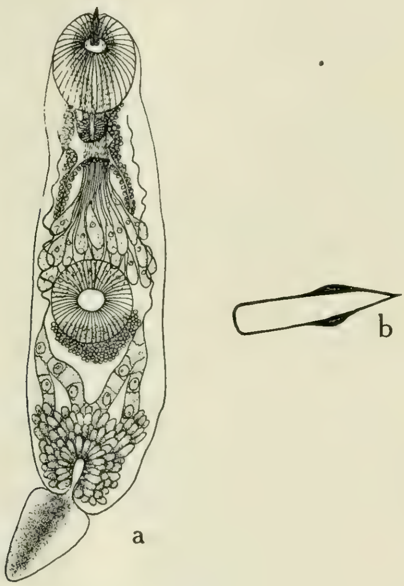

Fig. 9.—Mature *Cercaria trigonura,* (*a*) ventral view. X 260. (*b*) Stylet of same. X 866.

their tails developed as suckers. Whether there is any close relationship between the members of this group and the other forms now included within the microcercous cercariae is impossible to determine in the present state of our knowledge. It is therefore best to retain the name microcercous cercariae provisionally to cover all short-tailed forms which do not fit into other groups.

Such a cercaria was found in four out of the thirty-six specimens of *Campeloma subsolidum* from Hartford, Conn. The tissues of the body above and at the bases of the gills of these snails contained large numbers of free mature cercariae. There were also present rediae in

different stages of development in which only little differentiated germ balls could be distinguished.

This cercaria (Fig 9 a), for which I propose the name *Cercaria trigonura,* has an elongate cylindrical body and a very short heart-shaped tail. It is unable to swim freely in open water, but extends and contracts its body very rapidly. The tail bent ventrad and pushing against the substratum aids somewhat in locomotion and the oral sucker at times becomes attached. By this peculiar method the animal is able to make a little progress with a great deal of effort.

On the ventral surface of *Cercaria trigonura,* just at the base of the tail, is a slit-like opening, which extends forward a short distance and dorsad reaches up into the body. Opening into the cavity thus formed are large numbers of unicellular glands which stain very heavily with hematoxylin. The position and structure of this posterior gland suggests that it may function for adhesion. No activity which suggests such a function has been observed. Figure 9a shows the characteristic shape of the stylet of this species. The large bicornuate excretory vesicle lined with a layer of granular cuboidal epithelial cells is also characteristic.

Cercaria trigonura is unique among the microcercous cercariae in having a large posterior gland opening at the base of the tail and in its bicornuate excretory bladder. It differs from all except *Cercaria limacis* Moulinié (1856: 83, 163-164), in having a blunted tail which is not modified as a sucker.

Furcocercous Cercariae

The Furcocercous or forked-tailed cercariae are very imperfectly known. Although at least a dozen species have been reported as distinct, the anatomy of only a few of them is at all well worked out and the life history of no one of them has been determined.

Tangled masses of sporocysts containing a cercaria of this type were found in the livers of five out of the thirty-six specimens of *Lymnaea reflexa* from Chicago. The name *Cercaria douthitti* is proposed for this form. The sporocysts are long cylindrical tubes of varying caliber which are unbranched and very much tangled together. When the cercariae were freed from the sporocysts they moved around somewhat erratically by a vigorous vibration of the body and tail. The oral sucker was not fully developed, so that the creeping movement could not be accomplished.

Cercaria douthitti (Fig. 10) is a small cylindrical cercaria with eyespots and a tail considerably longer than its body. Although it has no stylet, the region back of the acetabulum is almost completely filled with eight large unicellular glands, which seem to be analogous to the

stylet glands in certain other forms. Two groups of ducts from these glands run forward along each side and pass through the oral sucker to open at the anterior tip.

Only one forked-tailed cercaria, *Cercaria ocellata* La Valette St. George (1855: 22-23), resembles at all closely in structure *Cercaria douthitti*. *Cerceria ocellata* is, however, almost twice as large as my species and has fin-like projections on the divided lobes of the tail.

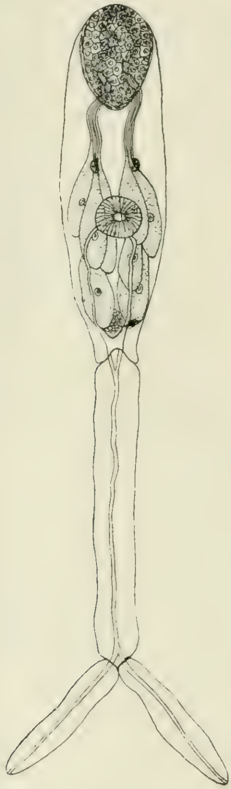

Fig. 10.—Mature *Cercaria douthitti*, ventral view. X 195.

Xiphidiocercariae

About one-third of all the known cercariae belong to the Xiphidio- or stylet cercariae. They are characterized as slender-tailed distome cercariae with a boring spine. As this group contains a large variety of forms, numerous subdivisions have been proposed. In my material are found five new stylet cercariae of four different types. Two of them are so much alike and agree so closely with several European cercariae that it is proposed to unite them into a new subgroup, which will be discussed next.

Polyadenous Cercariae

The name Polyadenous cercariae is proposed as a group designation for those of the Xiphidiocercariae which agree in the following characters.

1. Development in much elongate sac-shaped sporocysts.

2. Tail slender and except when much extended less than body length.

3. Acetabulum back of the middle of the body and smaller than the oral sucker.

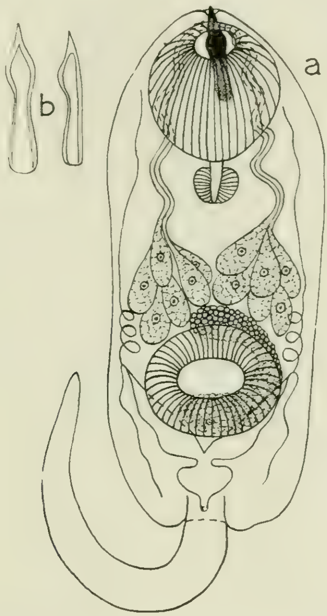

Fig. 11.—Mature *Cercaria isocotylea;* (*a*) ventral view. X 415. (*b*) Stylet of same. X 577.

4. Stylet about 0.030 mm. in length, six times as long as broad, and with a thickening about two-thirds of the distance from the base to the point.

5. Stylet glands six or more on each side between the acetabulum and the pharynx.

6. Excretory bladder bicornuate.

Two European fresh-water cercariae, *Cercaria limnaeae-ovatae* von Linstow, and *Cercaria secunda* Ssinitzin, can without question be placed in this group. I am able to add two American species, *Cercaria isocotylea* and *Cercaria polyadena.*

Cercaria isocotylea (Fig. 11a) was found in elongate, must twisted cylindrical sporocysts in 18 per cent. of 170 specimens of *Planorbis*

trivolvis from a drainage ditch northeast of Urbana, Ill. This cercaria moves actively both by swimming in open water and on a surface where it creeps with the aid of the suckers. When swimming, the body, which is turned with the dorsal side down, is bent slightly ventrad and the tail, which moves almost in a vertical plane, lashes rapidly. The locomotion is not very rapid and somewhat erratic.

This cercaria, except when much extended, is under 0.20 mm. in length. The tail is considerably shorter than the body and very slender. The acetabulum is almost as large as the oral sucker. The character-

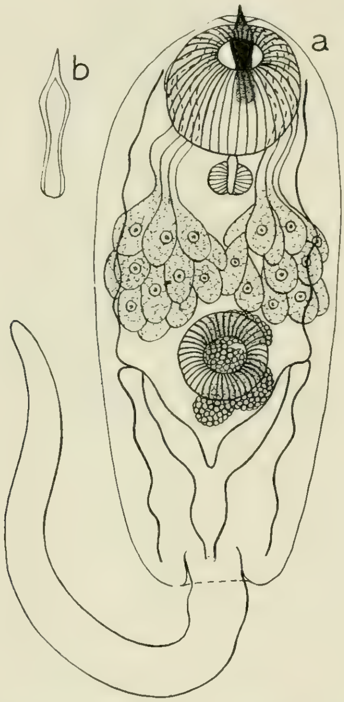

Fig. 12.—Mature *Cercaria polyadena;* (*a*) ventral view. Cystogenous glands not shown. X 415. (*b*) Stylet of same. X 577.

istic stylet is shown in Figure 11b, and the stylet glands form two groups of from six to eight in a group.

Cercaria polyadena (Fig. 12a), the second polyadenous form, was found in one of the specimens of *Lymnaea reflexa* from Chicago, which was also infected with *Cercaria reflexae*. The cercariae were contained in elongate unpigmented sporocysts, much like those of the former species. The movement of this cercaria is much like that of *Cercaria isocotylea*, and its stylet (Fig. 12b) is very similar to that of that species. It has, however, a larger body and tail, a smaller acetabulum and a larger number of stylet glands than *Cercaria isocotylea*.

Some facts are known of the further development of the polyadenous cercariae. *Cercaria limnaeae-ovatae* has been assigned to *Opisthioglyphe rastellus* (Olson), and Ssinitzin (1905) suggests that *Cercaria secunda* may be the larva of a *Plagiorchis* species. It is possible, therefore, that the American forms belong to Lühe's subfamily *Plagiorchiinae*.

Microcotylous Cercariae

Lühe's group of Cercariae microcotylae contains a number of very small Xiphidiocercariae, most of which are very insufficiently known. Besides the forms listed by Lühe (1909: 196-198) and *Cercaria caryi*,

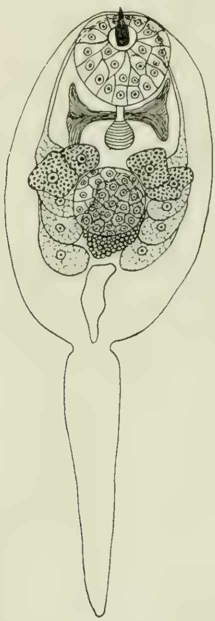

Fig. 13.—Immature *Cercaria leptacantha*, ventral view. X 433.

three Egyptian cercariae of Looss (1896: 227-232), *Cercaria cellulosa* sp. inq., *Cercaria pusilla* sp, inq. and *Cercaria exigua* sp. inq., should be placed in this group. An American species to be called *Cercaria leptacantha* is added from my material. The tissues above the gills in three of the thirty-six specimens of *Campeloma subsolidum* from Hartford, Conn., was infected with oval thin-walled sporocysts containing cercariae of this species.

The general structure of *Cercaria leptacantha* is shown in Figure 13. None of the cercariae were fully matured and but slight movement was noted.

Cercariae Ornatae

Lühe (1909: 190) defines the Cercariae ornatae as follows: "Distome Cercariae mit Bohrstachel, deren schlanker Ruderschwanz einen Flossensaum besitzt."

In this group are placed *Cercaria ornata* La Valette, and *Cercaria prima* Ssinitzin. From my material an American form, *Cercaria hemilophura,* is added. This group must very evidently be considered as merely provisional, since the three cercariae comprising it are very different in structure, having little in common except the presence of a fin-like projection from the tail.

A tangled mass of elongate, orange-pigmented sporocysts containing cercariae of *Cercaria hemilophura* were found in one of twenty

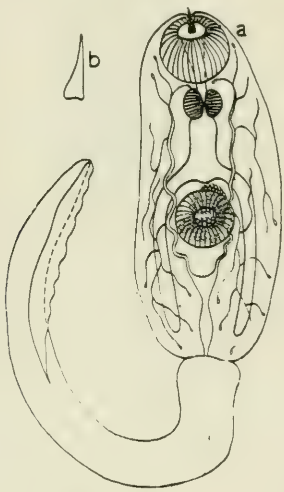

Fig. 14.—Mature *Cercaria hemilophura;* (*a*) ventral view. Cystogenous glands not shown. X 140. (*b*) Stylet of same. X 433.

specimens of *Physa gyrina* from Rockford, Ill. The sporocyst tubes do not branch and are of varying caliber. Club-shaped ends jut out from the mass and sway slightly backward and forward.

Cercaria hemilophura (Fig. 14a) is a large cercaria, over 0.40 mm in well-extended specimens, and its tail is about the length of the body. Along the ventral surface of the posterior half of the tail extends a fin-like projection which at its widest is about half the width of the tail. The stylet (Fig. 14b) is small, tapers regularly to a point and has no thickened region. The body contains large numbers of cystogenous glands, but no stylet glands could be distinguished. Other points of general structure can be made out from the figure.

The livers of three out of ninety-three specimens of *Physa anatina* from Manhattan, Kan., contained sausage-shaped sporocysts in which a peculiar kind of Xiphidiocercaria was developing. For this species the name *Cercaria brevicaeca* is proposed. No cercaria has been found in the literature which corresponds closely to this form.

The specimens of *Cercaria brevicaeca* examined moved clumsily and irregularly while swimming. Figure 15a shows the general points of structure. Very characteristic of this species is the stylet (Fig. 15b). Of the excretory system only the peculiarly shaped vesicle can be made out. This is composed of a pyriform median portion and two lateral parts which almost completely surround the acetabulum. Numerous cystogenous glands and two clumps of from ten to twelve stylet glands are present.

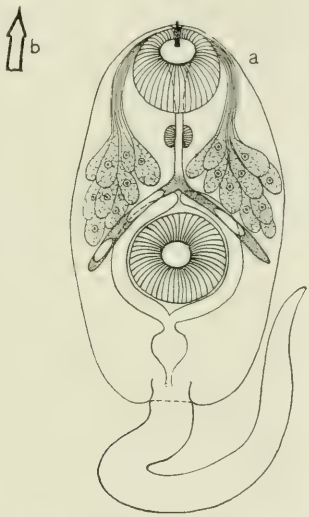

Fig. 15.—Free-hand drawing of *Cercaria brevicaeca;* (*a*) ventral view. Cystogenous glands not shown. X 150. (*b*) Stylet of same. X 433.

SUMMARY

Fourteen new cercariae were found in six species of fresh-water snails obtained from seven localities.

Of these one is a monostome, two are amphistomes and the others belong to five of the groups under the distomes.

Observations on the living cercariae show interesting locomotor activities.

The two amphistome cercariae described correspond closely in structure to *Diplodiscus temporatus* Stafford. Two different cercariae, one a large gymnocephalous form and the other a small stylet cercaria, which Cary described as being this species cannot belong to it.

A new subgroup of gymnocephalous cercariae, the megalurous or heavy tailed cercariae, is proposed; it includes *Cercaria megalura* from *Pleurocera elevatum* and *Cercaria distomatosa* Sonsino.

Cercaria polyadena and *Cercaria isocotylea* are made the basis of the polyadenous cercariae, a new subgroup of the xiphidiocercariae.

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NEW VARIETIES AND SPECIES OF MALARIA PLASMODIA *

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Although it has been nearly twenty-four years since Laveran announced his discovery of the parasites concerned in the etiology of the malarial fevers, and although an immense amount of work has been expended on the study of these parasites in the endeavor to arrive at a classification of them that can be accepted by all observers, we are still far from achieving that happy result, as is readily evident if one compares the classifications given by the authors of the most recent works on the subject. While most authorities agree that there are at least three species of malaria plasmodia, they do not all agree as regards nomenclature, and Laveran still adheres to the belief in the unity of all malaria plasmodia occurring in man, regarding the so-called species as variations in a single pleomorphous species.

In view of the evidence that has accumulated regarding the morphology, life cycle and relation to disease of the plasmodia of malaria, I believe, with most investigators, that several species of malaria plasmodia exist. The marked differences in the morphology of the species generally accepted, which are constant; the length of their cycle in man; the symptoms produced by their presence and the periodicity of the occurrence of these symptoms, all point to the conclusion that we are dealing with different species, while the fact that each plasmodium reproduces its kind when experimentally inoculated into man and with that reproduction gives rise to the characteristic clinical symptoms commonly produced by the species inoculated, makes the evidence in favor of distinct species practically conclusive. When to these evidences is added the fact that certain species of mosquitoes can only transmit certain species of the plasmodia, the evidence would appear to be incontrovertible.

As a matter of fact, Laveran is practically alone in his advocacy of the unity of the human malaria plasmodia, for the consensus of opinion among protozoologists is in favor of the plurality of species. While this is so, there is still considerable disagreement regarding the number of species which should be recognized and the classifications

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of Grassi and Feletti (1890), Mannaberg (1899), Sacharoff (1896), Lühe (1900), Schaudinn (1902), Doflein (1911) and others differ somewhat in this respect, although the majority recognize at least three species, the tertian, quartan and estivo-autumnal plasmodia. The names given these species also vary with different authorities, but if the generally accepted rules of nomenclature be followed, the tertian plasmodium must be called *Plasmodium vivax* (Grassi and Feletti), the quartan, *Plasmodium malariae* (Marchiafava and Bignami), and the estivo-autumnal, *Plasmodium falciparum* (Welch). While, as has been stated, nearly all authorities admit the existence of the three species mentioned, there is still considerable discussion regarding the existence of still other species, especially of species of the estivo-autumnal plasmodium. By many observers the plasmodia encountered in the malarial fevers generally known as estivo-autumnal are divided into two species, the subtertian or tertian, and the quotidian, while by some the latter is divided into a pigmented and unpigmented quotidian plasmodium.

During the past sixteen years I have had the opportunity of studying the plasmodia in thousands of cases of estivo-autumnal malaria and have reached the conclusion that two distinct species of plasmodia are concerned in the etiology of these forms of malarial fever, one sporulating in twenty-four hours, the other in forty-eight hours. These two species of plasmodia were first described by Marchiafava and Bignami, and there is no doubt in my mind that they can be distinguished morphologically and that, in uncomplicated instances of infection, they each produce a characteristic form of malarial fever. In previous communications (1901, 1909) I have described in detail the morphology and life cycle of these plasmodia and the symptoms produced by infection with them, and further research has only convinced me of the truth of Marchiafava and Bignami's classification of the estivo-autumnal plasmodia. Later (1909a) I proposed the name *Plasmodium falciparum quotidianum* for the quotidian species of the estivo-autumnal plasmodium, considering it a subspecies of the subtertian or tertian estivo-autumnal plasmodium, or *Plasmodium falciparum*. Accordingly, at the present time, I believe that there are four well-defined species of malaria plasmodia, namely, *Plasmodium vivax*, the tertian; *Plasmodium malariae*, the quartan; *Plasmodium falciparum*, the subtertian or tertian estivo-autumnal, and *Plasmodium falciparum quotidianum*, the quotidian estivo-autumnal.

Recently there have appeared contributions by two different observers describing new varieties or species of the malaria plasmodia. In view of the interest which must attach to the discovery of any new forms of these parasites in man, and as I believe that I have observed

plasmodia similar in every respect to those described in the contributions mentioned, it has seemed of importance to place my observations on record together with some critical comments regarding the subject. In April, 1914, in the *Proceedings of the Royal Society* and in the *Annals of Tropical Medicine and Parasitology,* J. W. W. Stephens (1914, 1914a) described what he considered a new species of malaria plasmodia of man, while in May, 1914, in the *Bulletin de la Société de Pathologie Exotique,* Ahmed Emin described (1914) a plasmodium which he regarded as a variety of *Plasmodium vivax,* the benign tertian plasmodium. Stephens has named the plasmodium observed by himself *Plasmodium tenue,* while Emin has named his *Plasmodium vivax* variety *minuta.* Both contributions are well illustrated by presumably correct drawings of the plasmodia described, else I would not feel justified in discussing the parasites, not having seen the actual preparations containing them. However, as I have repeatedly observed plasmodia answering in every detail to those described and illustrated in the papers referred to, I feel no hesitation in recording my observations in confirmation of the existence of these forms, although I cannot agree with all that is noted regarding the so-called *Plasmodium tenue* in so far as its classification as a new species is concerned. The plasmodium described by Ahmed Emin will first be considered.

PLASMODIUM VIVAX VARIETY MINUTA

This plasmodium was observed in the blood of pilgrims in the hospital at Camaran, an island in the Red Sea, about 30 miles from Hodeidah. Emin describes the plasmodium as resembling the benign tertian plasmodium (*Plasmodium vivax*), but differing from it principally in its smaller size, lack of enlargement of the infected erythrocyte, and smaller number of spores or *merozoites.* The pigment present in the plasmodium is fine and resembles that in *Plasmodium vivax.* At the time of sporulation the plasmodium almost entirely fills the erythrocyte, which is not enlarged, and from four to ten merozoites are produced by the division of the parasite. Ameboid motility is slight as compared with that of *Plasmodium vivax.* Multiple infection of the erythrocyte was not infrequently observed, and one of the drawings shows an erythrocyte containing as many as five schizonts in the "ring" stage of development. Emin believes that while there are marked differences between this plasmodium and *Plasmodium vivax,* it resembles the latter to such an extent that it should properly be regarded as a variety rather than a new species, and proposes the name *Plasmodium vivax* variety *minuta.*

In 1899 and 1900, while studying the malaria plasmodia observed in the blood of our soldiers returning from the Philippines, at the

U. S. Army General Hospital, Presidio of San Francisco, Cal., I observed a plasmodium in the blood of six patients answering to the description of the variety *minuta* of Emin, and my observations were published in the Report of the Surgeon-General of the Army (Craig, 1900). Emin's description of his plasmodium answers almost exactly to that of the plasmodia observed in these cases, and his drawings are accurate reproductions of the plasmodia that I observed. Since that time I have noted the same plasmodium in regions where only tertian infections are present, and I am in agreement with him in considering it to be a variety of *Plasmodium vivax*. The following is my original description of this plasmodium, as published in the Surgeon-General's Report:

"In studying the blood of soldiers returning from the Philippines and suffering from malaria, I have noticed in several cases a peculiar form of the malarial parasite which I have classified in reporting on the cases as a tertian parasite, but which presents so many differences from the ordinary tertian parasite as to indicate that it is a distinct variety of the plasmodium.

"I have invariably observed it in the blood of patients having tertian paroxysms and always in large numbers. All stages of the parasite have been observed, from the hyaline disks to the segmenting bodies. It appears first as a very highly refractive circular hyaline disk within the erythrocyte, having a sharply cut outline and no ameboid motion. The absence of ameboid motion differentiates it from all other young forms of the malarial parasites. The hyaline disk is about one-fourth the size of the infected corpuscle, which is normal in size and appearance.

"In a few hours the hyaline disk has grown to about one-half the size of the corpuscle which contains it and has become pigmented. The pigment exactly resembles that found in the ordinary tertian parasite, being finely granular and motile and distributed unequally throughout the parasite. The parasite is circular in shape and devoid of ameboid motion. The border of the parasite is very sharply defined and the protoplasm very refractive and sometimes finely granular. The infected corpuscle is unaltered in size and color and is not crenated or shrunken.

"In about thirty-eight to forty hours the parasite has nearly filled the corpuscle containing it, and the amount of pigment has increased. The parasite is circular in shape and presents the same refractive protoplasm and sharply cut border; the pigment is sluggishly motile, reddish in color and in the shape of fine granules. The infected corpuscle is normal in size and color.

"I have not as yet observed the presegmenting forms in the blood, but have seen several segmenting forms. These are much smaller than the ordinary tertian segmenting forms, and the greatest number of segments observed has been ten. The segments are oval in shape or perfectly round, sharply cut and refractive. The pigment is usually collected in a solid reddish-brown mass at the center of the segmenting parasite and is immotile."

After giving the differential points between this parasite and the other species of malaria plasmodia, consisting chiefly in size, shape, ameboid motility, number of merozoites and character and arrangement of the pigment, I call attention to the fact that "The differentiation of this parasite from the quartan organism is really much more difficult than is the case with the tertian or estivo-autumnal plasmodia. Indeed, I mistook them for quartan parasites until the clinical histories of the cases and certain peculiarities of the parasites caused me to study them more carefully." They differ from *Plasmodium malariae* in the lesser degree of ameboid motility, in the larger amount of and more finely granular pigment, and in having a human life cycle of forty-eight hours instead of seventy-two hours. In conclusion, I state:

"I believe that this parasite is either a distinct variety of the malaria plasmodia or that it is a tertian parasite which has acquired the characteristics described through some unknown condition of environment acting on the development of the organism."

It will be noted that in my original description I mention that ameboid motility was absent in this plasmodium, but further observations have proved that it is present, but very much less pronounced than in *Plasmodium vivax*. The round form of this plasmodium is well illustrated in Emin's drawings and the number of mérozoites mentioned by him, four to ten, agrees exactly with my own observations, the largest number I have ever noted being ten. My original description was based on the living organisms, but later observations on specimens stained with Wright's modification of the Romanowsky stain confirm Emin's description of the stained plasmodium. The chromatin stains very intensely and tends to collect near the periphery of the plasmodium after the latter is half grown and just before sporulation, while the pigment at this time collects at or near the center of the plasmodium, the merozoites frequently being arranged regularly around the mass of pigment, giving the plasmodium the typical daisy or "marguerite" appearance, often spoken of as being characteristic of the sporulating forms of *Plasmodium malariae*.

Emin states that he could not be sure whether Schuffner's dots occurred in the infected erythrocyte, but in my experience they do

occur, but much less frequently than in the case of erythrocytes infected with *Plasmodium vivax*, and the dots are smaller and less in number. I believe that those who have reported Schuffner's dots as occurring in erythrocytes infected with the quartan plasmodium (*Plasmodium malariae*) have really been observing the variety *minuta* of *Plasmodium vivax*, for it is with the quartan plasmodium that this plasmodium is most apt to be confused. Indeed, the resemblance of this variety of the tertian plasmodium to the quartan, so far as morphology goes, is much greater than it is to the tertian plasmodium, but the fact that the parasite is found only in cases having a tertian periodicity, together with the character of the pigment and its arrangement, definitely separates it from *Plasmodium malariae*, and demonstrates that it is closely related to the tertian plasmodium. In the stained preparations the fine pigment, the characteristic arrangement of the chromatin and the absence of "band forms" serve to distinguish this variety of *Plasmodium vivax* from *Plasmodium malariae*, but unless one is well acquainted with the morphology of the latter plasmodium this variety of the tertian parasite will almost certainly be confused with it.

The occurrence of all stages of development in the peripheral blood is sufficient to differentiate this plasmodium from either *Plasmodium falciparum* or *Plasmodium falciparum quotidianum*, while the large size of the organism and its general morphology definitely proves that it does not belong to either of these species.

From my own observations, which are confirmed by those of Emin, I believe that this plasmodium should be considered a variety of *Plasmodium vivax*, and that it should be known by the name given it by Emin, that is, *Plasmodium vivax* variety *minuta*. I do not believe that the evidence is sufficient to prove that it is entitled to specific rank.

PLASMODIUM TENUE

In two identical contributions published separately, Stephens (1914, 1914a) describes what he considers a new species of malaria plasmodium. This so-called species is described from the parasites observed in a single blood-slide sent Stephens by Major Kenrick, I.M.S., from Pachmari, Central Provinces, India. Both of the contributions are illustrated with the same drawings and demonstrate conclusively that the plasmodia present in this slide are all in practically the same stage of development, so that the species is described from only one stage of development, and that an early stage, before the development of pigment. This parasite Stephens has named *Plasmodium tenue*, and he states that he believes that it has affinities with the simple tertian plasmodium and with *Plasmodium canis* of the dog, rather than with the malignant tertian parasite.

Basing his deductions entirely on the stained preparation, Stephens considers the distinguishing features of this species to be extreme ameboid activity, scanty cytoplasm, and an amount of nuclear chromatin out of proportion to the volume of the parasite. The extreme ameboid activity is evidenced by the marked variations in the shape of the parasite, ring forms being rare, while the vast majority of the organisms present long, thin processes stretching across the infected erythrocyte, frequently multiple in number. The small amount of cytoplasm is contained within these filamentous processes. The nuclear chromatin appears out of proportion to the volume of the plasmodium, occurring in the form of rods, strands, forked masses, patches, etc. The chromatin is situated in the protoplasmic processes either as strands, rods or angular masses situated at the junction of the two processes. Stephens says: "Abundance of and marked irregularity in the distribution of the chromatin masses are characteristic of this parasite."

Stephens considers that this plasmodium differs from the malignant tertian plasmodium (*Plasmodium falciparum*) in possessing greater ameboid activity and in the abundance and irregularity of the nuclear chromatin, and from the simple tertian plasmodium (*Plasmodium vivax*) in being smaller, having more delicate ameboid processes, a larger amount of and more marked irregularity in the distribution of the chromatin, and in the rarity of typical "ring" forms.

From the description of this organism given by Stephens and the drawings which accompany the description, it is, to say the least, extremely doubtful if this parasite can be accepted as a new species of malaria plasmodium. Even though it differed from the known species to a much greater extent than is described, it would be entirely unjustifiable to describe it as a new species from the morphology of the parasite during only a small portion of the life cycle and from the organisms observed in a single stained blood-smear. The morphological details on which the species is based are inadequate to establish the species, especially as the plasmodium is undoubtedly in that stage of development, the young unpigmented stage, in which a differential diagnosis from *Plasmodium vivax* would be most difficult. As a matter of fact, Stephens states that he is in doubt as to whether Schuffner's dots occur in the infected erythrocyte, but admits finding one infected erythrocyte which was enlarged and showed Schuffner's dots. Regarding the morphology of the plasmodium observed in this erythrocyte, Stephens says: "Although I could detect no pigment in this parasite I was not otherwise able to distinguish it from a simple tertian parasite."

Admitting, as I believe nearly every protozoologist will, who has had an extensive experience with the plasmodia of human malaria, that the classification of this organism as a new species is not justified, owing to the fact that practically only one stage of development has been observed and that the morphological characteristics are not sufficient to base a species on, the question remains as to the exact position of this plasmodium which appears to possess some peculiarities not usually described for the well-known species of human plasmodia. From my own experience, I am convinced that all of the species of malaria plasmodia present at times, and from unknown or known causes, atypical generations, so far as morphology are concerned, and if specimens of blood containing such plasmodia be studied to the exclusion of others from the same infection, one is most apt to regard these plasmodia as varieties or new species. Time and again I have been on the point of describing such atypical plasmodia as new species and have only hesitated because of previous experience with similar forms. In many of the patients showing these atypical plasmodia continued observation has demonstrated that the atypical forms were replaced by typical examples of one of the well-known species, while in other instances a minute examination of the preparations would show that, while the atypical plasmodia were the most numerous, typical parasites of one of the recognized species did occur, though perhaps in very small numbers.

As regards the parasite described by Stephens as *Plasmodium tenue,* I may say that I have several times encountered exactly similar parasites, so far as I can determine from his description and drawings, in undoubted infections with *Plasmodium vivax,* and for this reason I believe that Stephens' plasmodium is a rather atypical form of *Plasmodium vivax* in the unpigmented stage of development. As claimed by Stephens, the evidence of ameboid activity is pronounced, but no more so than is frequently observed in preparations of blood containing *Plasmodium vivax* at a corresponding stage of development, while the extreme delicacy of the cytoplasmic pseudopodia is frequently observed in tertian infections in which quinin has been administered in insufficient dosage to kill the plasmodia, but sufficient to produce a stimulation of ameboid activity and consequently a greater number of cytoplasmic processes. The amount of chromatin present in Stephens' plasmodium is greater than is usually observed at this stage of development, but not greater than I have observed in plasmodia in undoubted infections with *Plasmodium vivax,* in which the parasites were in the same stage of development. At this stage of development the infected erythrocyte is very frequently not enlarged in infections with the ordinary tertian plasmodium, so that the lack of enlargement of the eryth-

rocyte is not a point in favor of a new species. As a matter of fact, the distortion in the shape of many of the infected erythrocytes, as shown in Stephens' drawings, is very characteristic of tertian infections, and the fact that the erythrocyte containing the single organism observed in a later stage of development (an organism which Stephens states he was unable to distinguish from *Plasmodium vivax* except for the absence of pigment) was enlarged and presented Schuffner's dots, is certainly good evidence that this parasite is a more or less atypical form of the ordinary tertian plasmodium, or *Plasmodium vivax*.

The reasons underlying the production of morphologically atypical generations of malaria plasmodia are obscure, but I am convinced that insufficient dosage with quinin, and perhaps with other drugs, often leads to the production of such plasmodia and that these plasmodia may retain for several generations morphological abnormalities produced by adverse agencies, either physical or chemical. We know that in the case of *Entamoeba histolytica* the character of the nucleus is absolutely changed by the administration of drugs that produce a cessation of the acute symptoms of dysentery, and there is no reason why the same should not occur in the instance of the malaria plasmodia. So marked are the changes produced in the morphology of *Entamoeba histolytica* by either chemical or physical conditions leading to the cessation of acute symptoms that the form of the parasite occurring when the dysenteric symptoms abate was long regarded by the best protozoologists as a distinct species of entameba, and I believe that it is only reasonable to admit that the same influences may cause atypical generations of the malaria plasmodia.

In proof of this assertion I may state that I have followed infections in which the plasmodia were very atypical, being modified morphologically by the exhibition of small doses of quinin, and have seen a return to normal morphology when the drug was discontinued. One of the most common effects of quinin is a great stimulation in the ameboid activity of the malaria plasmodia and an apparent stimulation in the division of the chromatin, as evidenced by the presence of delicate pseudopodia containing an abnormal amount of chromatin during the early stages of development of the plasmodia. I would not wish to be understood as claiming that this is the explanation of the morphology of the parasite discussed in this instance, but I am satisfied that *Plasmodium tenue* is an atypical form of *Plasmodium vivax*. I have observed identical forms, so far as can be judged from the description and drawings, not once, but a considerable number of times, in supposedly untreated infections with *Plasmodium vivax,* and many times in infections with this plasmodium after the exhibition of doses of quinin insufficient to kill the plasmodia.

However, whether or not this parasite is identical with *Plasmodium vivax,* it cannot be accepted as a new species until the morphology of the parasites during the entire human life cycle at least is studied, for the only claim it now has to specific rank is the presence of slight differences in morphology during a very limited portion of the human life cycle, that is, the early unpigmented stages of development when such differences are commonly observed even in the well-recognized species of plasmodia.

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THE POISON GLANDS OF THE LARVA OF THE BROWN-TAIL MOTH

(EUPROCTIS CHRYSORRHOEA LINN.)

Cornelia F. Kephart

It is well known that certain lepidopterous larvae possess urticating hairs which are the cause of a more or less severe and painful irritation when they come in contact with the human skin. In this country, the one which has attracted the most general attention on this account is the larva of the imported brown-tail moth, *Euproctis chrysorrhoea*. A great many cases of poisoning have been attributed to this species, and one death has been reported as the result of severe internal poisoning caused by inhaling the hairs.

There has been much discussion among scientists as to whether the effect of these hairs is purely mechanical or whether they are actually poisonous, but on the other hand, singularly little definite study has been made of the morphology of the hairs and their underlying structures. It was for this reason that the subject of this paper was suggested by Dr. W. A. Riley and to him the writer is greatly indebted for much kindly criticism and many helpful suggestions.

In 1894 Packard described the poisonous spines of *Lagoa crispata*, stating that the spines themselves were secreted by certain large trichogen cells lying under the rest of the hypodermis and connected with the spines through pore canals in the cuticle. In addition to these cells there were other smaller ones lying in different places above and below the hypodermis, and even in the pore canal itself, which he called "poison nuclei," and which he claims secrete the poison. Ingenitsky (1897) studied several different forms, especially *Ochneria monacha* Linn., and he clearly demonstrated that there are two cells connected with each hair and that the smaller of the two is the trichogen cell, which, after secreting the hair, decreases in size, and that the large cell is the actively secreting poison gland. Aside from the fact that Ingenitsky carefully traced the development of the two cells through all stages of the larva, this view would seem to be the reasonable one, because one would naturally expect to find that the actively secreting cell was larger than one that had already stopped its action. This latter is the same view as that expressed by Holmgren (1895). He also found that the poison hairs were connected with two cells, one somewhat larger than the other, one of which secreted the hair and the other the poison.

In all the forms studied by the different authors, however, the hairs were one of two general types. The first is a simple hair tapering from the base to the tip and containing a poisonous substance, the exact nature of which is not known. When one of these hairs comes in contact with the skin the point breaks off and the contents are liberated in the blood.

The second type is practically the same except that the tip of the hair is in the form of a more heavily chitinized cone which is fitted, cap-like, on the end of the hair and which is readily detachable. In this instance the hair remains on the larva, the tip only breaking off and entering the skin. This type occurs most frequently on the so-called slug caterpillars. These hairs are also said to contain poison, although there has been no evidence brought forward so far to prove that their action is anything more than that of a mechanical irritant.

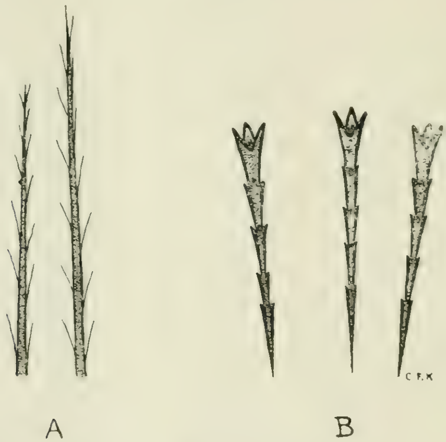

Fig. 1.—Hairs of a larva of *Euproctis chrysorrhoea*. *A*. Ordinary hairs. X 13. *B*. Poison hairs. X 300.

The poison hairs of the brown-tail caterpillar are of a very different type (Fig. 1, B). They are pointed at the base, gradually enlarge toward the tip and have three rows of barbs extending their entire length. They are heavily chitinized, and are filled with a granular substance similar in appearance to the contents of the underlying hypodermal cells. These hairs are found only on the subdorsal and lateral tubercles (Fig. 2, *sdt* and *lt*), arising in bunches of from three to twelve on minute papillae with which the tubercles are thickly covered (Fig. 3, *pap*). Tyzzer (1907) claims to have found as many as twenty on a single papilla, but the writer has not found more than twelve, five to seven being the usual number. They are 70 microns to 100 microns in length and 4 microns to 5 microns in thickness at the larger extremity.

There has been considerable doubt in the minds of many entomologists as to whether the hairs were really poisonous or whether they acted merely as mechanical irritants, but the experiments of Dr. E. E. Tyzzer seem to indicate that there is some specific poison in the hairs.

He found that if one of the nettling hairs be introduced into a drop of blood a peculiar change takes place in the red blood-corpuscles. To quote from his report: "They at once become coarsely crenated, and the rouleaux are broken down in the vicinity of the hair. The corpuscles decrease in size, the coarse crenations are transformed into slender spines which rapidly disappear, leaving the corpuscles in the form of spheres, the light refraction of which contrasts them strongly with the normal corpuscles. The reaction always begins at the basal sharp point of the hair. Minute particles of glass wool, the barbed

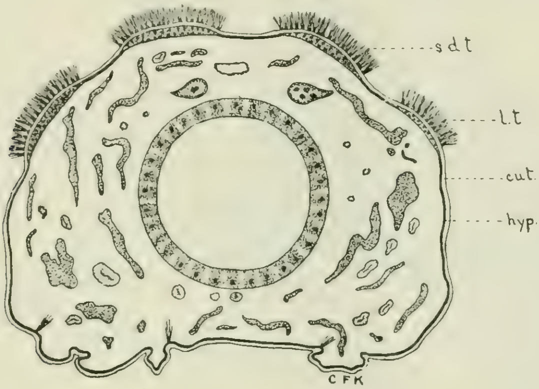

Fig. 2.—Cross section of a larva of *Euproctis chrysorrhoea* showing distribution of poison hairs; *sdt*, sub-dorsal tubercle; *lt*, lateral tubercle; *cut*, cuticle; *hyp*, hypodermis.

hairs of a tussock moth, and the other coarser hairs of the brown-tail, all failed to produce any effect on the red blood-corpuscles." These experiments I have repeated with the same results.

Dr. Tyzzer then tried the effect of heating on the activity of the hairs and found that after baking them for an hour at 110 C. they still gave a typical reaction with the red blood-corpuscles and produced the typical dermatitis when rubbed on the skin. But he found that after baking for an hour at 115 C. they failed to react on the corpuscles, and when rubbed on the skin produced only a slight redness and irritation, such as is caused by any foreign body penetrating the epidermis. All these facts seem to show that there is a definite poisonous substance either in or on the hairs.

He next tried a number of reagents to determine the solubility of the irritating substance. He found that acetone, alcohol, chloroform

and ether had no effect on the reaction of the hairs, whether they were boiled in it or left for days at room temperature. I have found, however, that the hairs from caterpillars that had been kept for five weeks in 70 per cent. alcohol failed to have any effect on the red blood-corpuscles, while those from the cast skins of larvae which had been kept in a dry place for several months produced the characteristic reaction when introduced into a drop of blood. "The nettling hairs remain active after being boiled in pyridin, which boils at a temperature between 106 and 108 C. They also remained active when kept for several days in glacial acetic acid, in 0.5 per cent. acetic and in both 1 per cent. and 0.1 per cent. HCl." But when they were left over night in 1 per cent. and 0.1 per cent. solutions of KOH and NaOH they failed to react either on the skin or on the red blood-corpuscles.

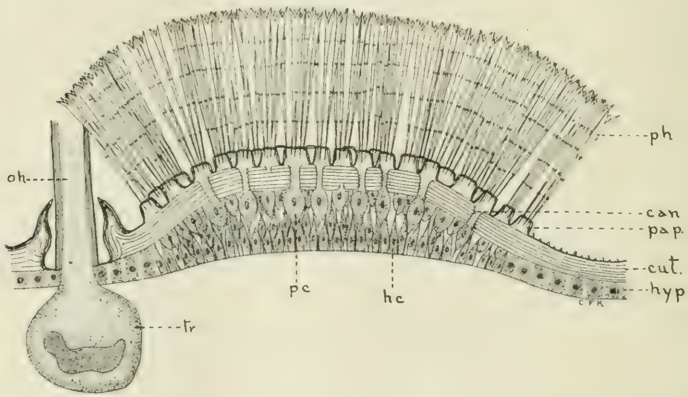

Fig. 3.—Enlarged section of a tubercle; *oh,* ordinary branched hair; *tr,* trichogen cell; *ph,* poison hair, *can,* pore canal; *pap,* papilla; *pc,* poison-secreting cell; *hc,* hair formative cell; *cut,* cuticle; *hyp,* hypodermis. Studied under low power, arrangement of cells semidiagrammatic.

This difference in the action of the weak acids and the weak alkalies is not surprising, since the blood fluid is itself alkaline and the poison is soluble in it.

The next question which arises is whether the poisonous substance is contained in the hair or is merely smeared on the outside, as a number of writers suggest.

If it is on the inside there must be a pore, or opening, of some kind in the point of the hair, because, as has already been stated, the reaction of the red blood-corpuscles always begins around the basal point of the hair and gradually spreads from there, except in the instances where the hair has been broken, when the action takes place rapidly around the point of fracture. In the poison hairs of certain other forms, a tiny opening in the point of the hair is distinctly visible,

but it has been impossible so far to detect any such pore in the poison hairs of the brown-tail caterpillar even with an oil emersion lens.

If the substance is merely smeared on the outside, however, what is its source and how does it reach the hair? If, as some writers suggest, it is secreted in the two red tubercles on the caudal end of the body, then the long hairs as well as the short ones would be covered with it. This has not proved to be the case. Furthermore, Dr. Tyzzer found that if a hair be dried and then placed in some such stain as Loeffler's alkaline methylene-blue solution, the dye first penetrated the point of the hair and then gradually diffused throughout its entire length. These observations strongly indicate that there is a pore in the point of the hair, but there is one thing that Dr. Tyzzer seems to

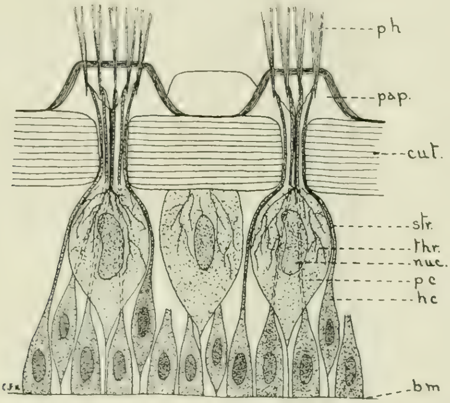

Fig. 4.—Diagram of arrangement of hairs and cells; *ph,* poison hair; *pap,* papilla; *cut,* cuticle; *str,* prolongation of hair formative cell; *thr,* threads of poison; *pc,* poison-secreting cell; *nuc,* nucleus of poison secreting cell; *hc,* hair formative cell; *bm,* basement membrane.

have overlooked. As he says, the nettling hairs occur in groups inserted point first in protuberant rounded sockets or papillae on the subdorsal and lateral tubercles. These papillae are set very close together, although not actually in contact with each other.

Now the hairs of insects are formed simply by the outpushings of certain hypodermal cells, which, projecting above the general level, secrete their cuticle in the form of hair-like prolongations of chitin. The projecting hairs would therefore be hollow and their contents connected directly with the contents of the underlying cell. Then, since the hairs under consideration are inserted point first, this connection must be through the point, and this would leave a pore, or opening, through which the poison may diffuse into the blood when the hair is detached.

The hypodermis of the subdorsal and lateral tubercles is very different in appearance from that of the other regions of the body, being much thicker. This increase in thickness is due to the great length of the cells which lie directly beneath the poison hairs. They are all much elongated, three or four times the length of the ordinary hypodermal cells, and are closely crowded together. The connection between the cells and the poison hairs is effected through pore canals in the cuticle the same as with the ordinary hairs, the only difference being that instead of there being a pore canal for each hair there is one for each papilla on the tubercle, all the hairs on a papilla being reached through the same pore canal (Figs. 3 and 4).

The cells are divided into two groups, one composed of large cells 3.3 microns in diameter, the other composed of smaller ones 1.95 microns to 2.02 microns in diameter. The cells of the first group lie directly under the cuticle (Fig. 3, *pc*) and have crowded out the smaller cells toward the basement membrane, which gives a two-rowed appearance to the hypodermis. These large cells, one of which lies directly under each of the hair-bearing papillae, are composed of granular cytoplasm, corresponding in appearance with that of the ordinary hypodermal cells, with large nuclei which, however, are smaller in proportion to the size of the cell than those of the other group (Fig. 4, *nuc*). In the cytoplasm there are fine threads of a darkly staining substance which converge toward the apex of the cell and unite into a coarser thread which passes through the pore canal in the cuticle and enters the papilla. There it divides again, one thread going to each of the hairs on the papilla (Fig. 4, *ph*).

At first sight these cells bear a slight resemblance to nerve cells with nerve fibers running out from them; but they are rather the poison-secreting cells and the threads, coagulated secretion connected with the individual hairs. This would seem to be the case for three reasons: In the first place, there are no other cells remotely resembling these in any part of the body; this fact in itself being enough to preclude the possibility of their being nerve cells. In the second place, suppose that they were really nerve cells and the hairs instead of being poisonous were merely sensory. What would be the object of having sense organs so loosely attached to the body of the insect that the slightest touch suffices to dislodge them? And what could be their use? Obviously, they could not be tactile, because they are so very short that practically nothing could get to them through the long hairs with which the body is thickly covered. It would take something more stable to serve the purposes of hearing and as for the chemical senses, taste and smell, they are so absolutely different from any other organs of that nature that such a supposition would be unlikely on the face

of it. If sensory, they would seem to be of some sense with which we are unfamiliar and one peculiar to this particular species of caterpillar, especially fitting it for its mode of life. Since its habits are not markedly different from those of a great many of our social caterpillars, the writer is at a loss to account for the necessity of such a highly specialized sense.

Then, since they are evidently not nerve cells, and since they are actively secreting, it would seem legitimate to assume that they are poison cells. The hairs themselves are formed by the smaller cells, as will be shown later, the papillae are merely cuticular appendages and there is nothing else present for which active gland cells could possibly be used.

The cells composing the second group are of a very different appearance from those just described. They are much smaller; measuring from 1.95 microns to 2.02 microns in diameter. They are fusiform in shape, irregularly arranged, and appear as though crowded out of their regular position by those around them. There is comparatively little cytoplasm and it does not contain the threads of poisonous substance (Figs. 3 and 4, *hc*). These cells correspond in number with the hairs and each cell is connected by means of a strand of cytoplasm with a hair. The strands of cytoplasm are in fact nothing more nor less than portions of the cells which extend up around and between the poison cells (Fig. 4, *str*), through the pore canal and papilla directly to the hairs. In other words, the smaller cells are the hair formative cells for this particular kind of a hair.

The basement membrane extends along beneath the second group of cells and is very easily detected, much more so in fact than in the other parts of the body wall; and all the cells, whether poison-secreting or hair formative, are connected with it either lying directly on it or connected by means of fine threads of the cell substance.

Beille (1896) described something very similar to this as obtaining in one of the processionary caterpillars, *Cnethocampa pityocampa* Borowski. In that species the surfaces of the tubercles bearing the urticating hairs are divided into four areas by two bands which cross the tubercle at right angles to each other and which are free from hairs. The four sectors thus made are covered with chitinous papillae which bear the poison hairs and which are connected with the subjacent parts by pore canals in the cuticle in the same way as those of the brown-tail. "The glandular part exists only under the sectors covered with hairs. These glands are separated from each other by connective-tissue strands and a membrane of the same nature separates them from the subjacent organs. These glands are unicellular and are in the form of very elongate pears. . . . In the narrower parts one sees a canal

which is continuous with each of those which cross the chitinous area. These glands are therefore analogous in their structure to those which correspond to the large hairs, and ought to be considered as hypodermal glands."

Unfortunately, there are no illustrations in his paper, and it is somewhat difficult to interpret his descriptions. He says nothing to prove the glandular nature of these cells, and the probability is that some of those that he describes are the hair-formative cells. Judging from the brown-tail, his connective tissue strands are the prolonged distal portions of the hair formative cells. However, that a condition exists similar to that found in the brown-tail seems probable and it is quite probable that further work done on the larvae of the processionary caterpillars will bring out still further evidences of the similarity of their structures.

Probably the nearest approach to the structures found in the brown-tail are those recently described by Eltringham (1914) as occurring in the closely related species *Porthesia* (*Euproctis*) *similis* Fuess. He says that these hairs are connected with *two* rows of hypodermal cells similar to the one row in Figure 3, which cells, he thinks, doubtless secrete the hairs. If two rows of hypodermal cells do exist in this form it is an aberrant condition, and from Eltringham's description and figures it seems probable that what he took for a second row of cells was either an invagination of the body wall, a portion of the hypodermis from some other part of the body which had become displaced in the process of sectioning, or else some other tissue entirely.

There are also figured some very peculiar looking structures which he calls the "plume-like structures." These are said to occur among the urticating hairs and to "arise from a chitinous socket, differing little, if at all, from the sockets of the larger branched hairs, and having at its base several cells apparently of a glandular nature." These "plume-like structures" correspond in position to some of the large branched hairs of the brown-tail and it is possible that what Eltringham took for a single structure is really a group of branched hairs, each hair being connected with one of the cells at the base of the structures.

More work will have to be done on all the poisonous forms before generalizations can be made, but, taking all things into consideration, it is clear that the short barbed hairs occurring on the subdorsal and lateral tubercles of *Euproctis chrysorrhoea* contain a definite poisonous substance and do not act merely as mechanical irritants; and it is probable that a similar condition of affairs exists in a number of different species.

SUMMARY

1. Tyzzer's statement that a definite poisonous principle is contained in the short barbed hairs of the larva of the Brown-tail Moth is confirmed.

2. This substance is secreted by certain specialized hypodermal cells and is liberated in the blood through the sharp basal point of the hairs when they come in contact with the human skin.

3. The poison glands are larger and fewer in number than the cells which form the hairs, there being one poison cell for each papilla on the tubercle instead of one for each hair.

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AN APPEAL TO AMERICAN HELMINTHOLOGISTS

Al. Mrázek
Professor of Zoology, Bohemian University, Prague

Some years ago the muskrat was introduced into Bohemia. This animal has not only taken possession of his new home, but soon overspread the whole country and is now continuing his conquering course beyond the boundaries of Bohemia in the neighboring lands of Bavaria, Saxony, etc.

This fact is certainly in zoogeographical respects a very interesting one. It offers, so to speak, an academic instance for demonstrating some general biological laws concerned in the geographical distribution and spreading of animals, an instance that especially for American zoologists would be of some interest as relating to a well known representative of the North American mammalian fauna.

But it is not my intention to dwell here on this point. Nor yet on the economic side of the introduction of the muskrat into Bohemia which has proved to be most disastrous to pisciculture in our country by its destructive action (burrowing in the pond dams, etc.), although this side might be also of some interest to the American zoologists interested in the economic aspect of the science. The muskrat as a fur-bearing animal is of economic importance, and the experiences we have had in Bohemia on the possible, incredible rate of increase in number of individuals, would perhaps give some hints for protective measures in North America.

I will only call attention to the parasitological side of the muskrat problem. It is obvious that a detailed study of the parasitological fauna of the muskrat in his new environmental conditions in Bohemia, respectively Europe, might throw some light on several general problems of parasitology.

I have myself already commenced this study, but I soon learned with regret and to my discomfiture, that the indispensable comparative basis for such studies, a knowledge of the parasites of the muskrat in his original American home, is lacking. I find this confirmed in a paper recently published by an American colleague, Professor Barker (Lincoln, Neb.), who also states that very little is known on the parasites of the muskrat. For this reason I beg to draw the attention of American helminthologists to this point and recommend to them the study of the parasites of one of the most typical North American mammals.

I am sincerely glad that I have the opportunity to publish this appeal in the columns of a new American journal devoted to the study of parasitology. I greet and welcome this journal and I am sure that it will contribute much to the general progress of parasitology.

KILLING SMALL ARTHROPODS WITH THE LEGS EXTENDED

R. A. Cooley
Entomologist, Montana Agricultural College, Bozeman.

Any one who has worked with alcoholic ticks recognizes the disadvantage of the curled position of the legs which is usually assumed in such specimens. In connection with experiments in methods of preserving female ticks in various stages of engorgement, it was accidentally learned that flat or unfed females, and all males, are left with the legs extended if killed by dropping into boiling water. Specimens so treated also become slightly distended, which is often an advantage.

The ticks are dropped, one at a time, from a height of 6 or 8 inches into a small dish of water over a flame. A pair of fine curve-pointed forceps is used for picking up and dropping the ticks, and a minute strainer on a handle is convenient for removing them from the water. Specimens which are removed as quickly as possible have the legs properly extended, but we have not observed any injury to others allowed to remain immersed longer.

Partly engorged females are improved as specimens if treated in this way, but larger females may be overdistended or may be injured by a cracking and slipping of the integument. Nymphs killed in this manner make better specimens, and it is probable that larvae would also be improved, though we have not tried the method on them.

Assistant Entomologist J. R. Parker has tried this method in killing aphids before clearing in turpentine-carbolic acid mixture, and finds that the legs are generally extended in symmetrical positions as with ticks. In the case of aphids this is apparently due to the legs being fixed in the position they have when they touch the water rather than to an extending of the legs after immersion. With ticks and aphids at least, this method appears to be of great value, and it is probable that with many other arthropods its adoption would be beneficial.

In this connection it may be of interest to state that living, unfed ticks may be induced to extend the legs by squeezing them lightly between two pieces of glass. In this position they may be photographed or examined under a binocular microscope without injuring them. For this purpose we have used a thin microscopic slide on one side and a seven-eighths by 2-inch cover-glass on the other, the two being held together by rubber bands. The cover-glass curves and touches the slide at both ends, and the amount of pressure on the tick is governed by varying the distance between the two rubber bands.

SOCIETY PROCEEDINGS

THE HELMINTHOLOGICAL SOCIETY OF WASHINGTON

The twenty-first regular meeting of the society was held at the residence of Mr. Crawley, Sept. 22, 1914, Mr. Crawley acting as host and Mr. Foster as chairman. Dr. R. T. Shields of Nankin, China, was a guest of the Society.

Mr. Crawley gave a demonstration of a Leitz microscope, designating some of the recent improvements.

Dr. Shields gave a talk on the parasites of man and the domestic animals around Nankin.

Mr. Hall reported a second case of *Fasciola magna* in the sheep. The fluke was found in a liver sent in from Ovando, Mont., where a number of sheep had died. These sheep showed black markings of the omentum and abscesses of the liver, lungs or spleen. A spleen that was sent in was very much enlarged and full of what appeared to be embolic bacterial abscesses. *Fasciola magna* in cattle apparently exerts little influence on the health of infested cattle. It is however, rather interesting to note that in this case and in the first case of *Fasciola magna,* reported by Hall in 1912, attention was called to the presence of the parasite by the fact that numbers of sheep were dying in each case. It seems very likely that *Fasciola magna* exerts considerable effect on the general health of infected sheep, even causing death in a rather high percentage of cases, but this is a matter that needs further investigation. In the previous cases the sheep were noted as showing emaciation, edema and peritonitis.

MAURICE C. HALL, *Secretary.*

NOTES

For the purpose of extending the investigations and experimental work relative to the parasites of live stock, the Zoological Division of the Bureau of Animal Industry has obtained a farm near Vienna, Va., where a study will be made of various problems in the control and eradication of the internal parasites of sheep.

The University of Illinois has begun the publication of a quarterly series entitled Illinois Biological Monographs. The first, a double number, is devoted to A Revision of the Cestode Family Proteocephalidae by George R. La Rue. Extended notice will be given this paper in a later number of the JOURNAL.

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SPIDER POISON

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The not-infrequent occurrence of the notorious "black widow" spider, *Latrodectes mactans,* in the vicinity of Stanford University, has led me to a limited personal attention to the subject of spider poison and its effects. For this spider, as is well known, has the unsavory reputation of being one of the most poisonous of all spider kinds. The matter was given an added interest for me when Dr. E. H. Coleman, a young graduate in medicine beginning a practice in the village of Los Altos, 5 miles from the university, and registered with me as a graduate student, reported a personal knowledge of two cases of the biting of human beings by Latrodectes, both of the cases resulting in an immediate serious condition of the patients. Dr. Coleman, in his turn, became much interested in the spider and its poison and besides noting and recording very carefully the effects of the poison on his patients, was led to the preparation of a much-diluted extract of the poison, with which he experimented on cats and rabbits and even on himself with no uncertain results, and later, under very interesting circumstances, on a patient suffering from angina pectoris.

The genus Latrodectes contains several species which are scattered widely over the world. A species (*L. malmigniatus*) of South Europe, is familiarly known and feared under the common name of "la malmigniatte" and another species of New Zealand is called "Katipo" by the natives, and is also much feared. In the two American continents three species occur, of which the most widely distributed and abundant one is *Latrodectes mactans,* which has a range from the northern boundary of the United States to Tierra del Fuego. It is a common spider in our Southern and Southwestern states. Of the other two American species, one (*L. curacaviensis*) is recorded only from the West Indies and the eastern countries of South America, while the other (*L. geometricus*) is called by Petrunkewitsch a tropical species, but Comstock states that it has been taken in California. It certainly is not familiar here.

All the species agree in general appearance and size, the female, which is much larger than the male and with nearly spherical abdomen, while the male has a more elliptical abdomen, being about 12 mm. in length and sooty-black or dark brown in color, with a conspicuous small blotch or blotches of vivid red on the under side of the abdomen. This blotch or pair of fusing blotches has the rough outline of an hourglass. However, it varies much in shape. The position of the spot and its vivid color contrasting with the sooty background are its distinguishing characters.

The species of Latrodectes seem to be feared wherever they occur. Comstock quotes Cambridge as referring to them as "those very interesting spiders which, under various local names, have been notorious in all ages and in all regions of the world where they occur on account of the reputed deadly nature of their bite." But to this Comstock says: "It may be added that this belief is not shared by students of spiders, and has probably been suggested by the strongly contrasting colors of the more common species which make them appear venomous to the credulous observers." To this I may in turn add that at least one student of spiders, though incomparably less experienced than Comstock, does share the belief in the unusually poisonous nature of *Latrodectes mactans*. This belief is based chiefly on the notes of Dr. Coleman, which are printed herewith.

But there are other printed records of presumable trouble from Latrodectes bites, and still other records which have been given me verbally from a few sources here in California, that bolster up this belief. The best known printed records of the effects of presumable Latrodectes bites in this country are those published in 1889 in Insect Life (vol. I, pp. 204-211, and 280-282).

Dr. Coleman's notes of the effects of Latrodectes poison on a patient, on himself and on cats and rabbits are, in his own words, as follows:

EFFECTS ON A BITTEN PATIENT

Patient B. came to my office one morning at 8:15 o'clock, showing signs of an acute poisoning of some sort.

The glans of the penis had been bitten by a spider while the patient was sitting in an outcloset. The only thing felt was a sharp sting. (The spider was captured so there is no doubt as to the species; it was a female of *Latrodectes mactans.*) In about ten minutes there appeared dizziness and weakness of the legs, followed by cramps in the abdominal muscles.

The patient left the field where working and started to walk to town, a distance of a little over a mile. The pains grew worse and the penis started to swell and turn red. When the office was reached, the pains, of a cramp-like character, in the abdomen, were intense, also around the heart and thighs. Physical examination showed the heart to be running at the rate of 40 per minute, of small volume but regular. The respiration was labored. The pupils were dilated and face very red and congested. The penis was swollen to a great size, fully 3 inches in diameter at the glans, and the color was a mottled

purple. The contractions were clonic in character, giving the greatest pain in the chest and abdomen. There were no pains below the knees or elbows.

The treatment consisted of hypodermic injections of strychnin 1/40, followed in ten minutes by nitroglycerin 1/100. Local applications to the side of bite of the crystals of potassium permanganate. The heart went to as low as 27 beats to the minute. After three hours' work, using repeated injections of strychnin, the heart-rate was increased to 45. The pains were not quite so severe and the patient was taken home. The administration of strychnin was stopped and the use of brandy hypodermatically was substituted, a dose of 10 mm. being given every hour. Heat was applied to the feet and back. At 5 p. m., or about nine and one-half hours after the first symptoms, the heart-rate had been raised to 55 and then as the pains were still severe, a ¼ morphin with 1/150 atropin was given. The pains eased up and the patient dropped to sleep.

The next morning a fine rash appeared all over the body, accompanied by some itching. The penis had returned to nearly normal in size. The heart-rate was 60, the respiration 18 and deep, temperature 100. The rash disappeared in four days. The patient was troubled with insomnia for several days, and a stubborn constipation that took a very active purge to affect.

Three years have elapsed and the patient has a heart-rate of about 64. No history of what it was before poisoning. Troubled with attack of insomnia and a marked bulimia.

EFFECTS OF THE EXTRACTED POISON ON THE EXPERIMENTER

The poison glands of a female Latrodectes were dissected out. The sac contained a very small drop of liquid of a white viscid character. The sac and contents were macerated in 10 drops distilled water, called solution No. 1, for several minutes. To this was added 100 grains of pure sugar of milk and the mass triturated for fully ten minutes. This was labeled No. 2. Ten grains of No. 2 was added to 90 grains of fresh milk sugar and triturated, making No. 3. Tests were made with trituration No. 3 or a 1/1,000 gr. of the poison in each grain; and also No. 2 with practically the same results, except that No. 2 was vastly stronger than No. 3.

Using No. 3, I made powders containing 2 grains each and took one powder every hour for ten doses, or 0.002 grain poison per dose. (My condition before starting test was pulse 72, respiration 18, temperature 98, bowels regular daily and no pains or aches.) At the end of ten hours no change could be felt, other than a decrease in heart action to 64. No powders were taken from 8 p. m. until 7 a. m. the second day. When 15 powders were taken, the heart action was 60, and a slight dull occipital headache. The bowels did not move at their regular hour in the morning. When 20 powders were taken, the heart-rate was 54, the occipital pain was quite severe, cramping pains were extending from the chest to the abdominal muscles, the pupils slightly dilated, and some distress about the heart. Again no powders were taken during the night; but I was very restless and could not sleep. Continued the powders on the third day and stopped when the twenty-fifth had been taken. The heart-rate was 48, temperature 99, very severe headache, clonic spasms of the thoracic or abdominal muscles, marked distress about the heart with radiating pains extending to the left arm-pit and down to the elbow; had no bowel action for two days; pupils markedly dilated. It seemed a perfect picture of angina pectoris. The symptoms gradually subsided and in three days felt normal. I allowed a period of two weeks to intervene and repeated the experiment with the same symptom-complex picture. The trial was repeated a third time, with always the same results, as to occipital headache, constipation and clonic spasm of the muscles of chest and abdomen; also the pain and distress about the heart. I was unable to persuade any of my friends to try out the drug, so am limited to my own symptoms for a drug picture in the human species.

EFFECTS OF THE EXTRACTED POISON ON RABBITS, CATS AND DOGS

Several experiments were tried on rabbits and cats with very interesting results.

1. The dissected glands of one female Latrodectes containing the virus. The virus was macerated in 10 drops distilled water. The same was injected subcutaneously into the abdomen of a cat about 8 months old. In about five minutes a series of convulsions set in of a clonic type, quickly followed by a tonic spasm and in ten minutes the animal was dead.

2. A pair of glands were macerated in 10 gtts. of water and diluted to 100 c.c. Ten gtts. of this dilution were injected into the abdomen of an 8-months-old cat and there resulted in five minutes dilatation of the pupils, unsteady gait, drooling of saliva, followed by a series of clonic spasms. The heart-rate lowered markedly and the abdomen swelled up to a large size. The feces and urine were passed involuntarily. Death occurred in forty-five minutes after injection.

3. A quantity of the eggs of the Latrodectes was macerated in 20 gtts. of water and diluted up to 10 c.c. The injection of this solution produced the same typical symptoms and death to a cat 8 months old in about three minutes. A rabbit was killed in about two and one-half minutes.

Ten c.c. of the same solution was injected into a dog about 2 years old and weighing 35 pounds, but there was no marked effects, except a lowering of the heart-rate; no death or convulsions. This experiment was not repeated.

EFFECTS OF THE EXTRACTED POISON ON A CASE OF ANGINA PECTORIS

The most interesting test of the poison was on a man 54 years of age, Mr. E., who had been troubled with pain and distress about the heart; pains that were of a constricting nature and which radiated to the arms. A good case of angina pectoris. A rigid position when the spell was on, clutching at any support, dilatation of the pupils and slow heart action. This patient had had several of these attacks, which continued intermittently for about one-half hour at each seizure. During one attack I gave one 2-grain powder of the No. 3 trituration or one hundredth dilution and in ten minutes the attack passed away, leaving the patient more comfortable than after any previous attack. This follows the "similia similibus curantur" of the Hahnemannian teaching and surely worked wonders in this one instance. No opportunity to repeat the trial, because one month later the patient was taken with another attack of a similar nature and before help could reach him, passed away.

These observations and experiments of Dr. Coleman seem to me to be of themselves sufficient evidence to show the really deadly character of Latrodectes poison. But there is other evidence of similar import, obtained in a different way. It is the evidence from the work of the Germans, Sachs and Kobert, on the hemolytic effects of spider poison, and the isolation from the spider body of a specific poisonous principle named "arachnolysin," which is a powerful hemolysin, proved by experiment to have very definite action on the blood of various animals, such as rabbits, rats, mice, geese and man.

Dr Hans Sachs (Beiträge zur Chemischen Physiologie und Pathologie, vol. ii) records the results of a study of the hemolytic action of the poisonous principle in the body fluid and poison glands of the diadem spider, *Epeira diadema*. The author first refers briefly to the present status of the general knowledge of the hemolytic effects of spider poison. By spider poison is not meant necessarily simply the

secretion of the poison glands, but also that substance carried by the body fluids or body tissues which seems to have, as well as the specific secretion of the poison glands, a poisonous effect on other animals. The author then describes elaborately the technic by which he made the extraction of a poisonous principle from the crushed and macerated whole body of the spider. This principle, the arachnolysin, causes, almost immediately, a dissolving of the sensitive blood corpuscles when introduced into blood taken from various birds and mammals, including men. In its behavior the arachnolysin shows a certain analogy with the venom of serpents and is distinguished by its immediate effects from the hemolytic behavior of blood-serum which acts only after a longer or shorter period of incubation. Curiously enough, the diadem spider's poison had no effect on the blood of guinea-pigs, dogs, sheep or horses. Its strongest effect was on the blood of rabbits and rats, next on mice, next on that of man, next on that of the ox and last, although still fairly strong, on that of the goose. A diadem spider of 1.4 gr. contains sufficient poison to destroy completely all the corpuscles in 2.5 liters of rabbit blood. This puts arachnolysin in the class of the strongest kinds of blood poisons.

Arachnolysin is easily destroyed by high temperatures. If it is exposed to forty minutes' continual heat of from 70 to 72 C. it is wholly destroyed. It can withstand a temperature of 56 C. for forty minutes, while a temperature of 60 C. for forty minutes reduces its effects only slightly. It can be preserved in glycerin for months in full strength of effect.

Sachs made experiments on immunizing, but they were limited by lack of material and he gives very little account of them. However, he mentions that shortly before his work was finished he was able to produce a highly effective antitoxic serum by treatment of the blood of guinea-pigs with arachnolysin; 0.0025 c.c. of this antitoxin serum is sufficient to protect 0.05 c.c. of rabbit blood from an otherwise hemolyzing dose of arachnolysin.

Kobert (Lehrbuch der Intoxicationen, 1893; and Beiträge zur Kenntniss der Giftspinnen, 1901) describes his studies of the poison of the diadem spider and also of Latrodectes. He distinguishes between the actual secretion of the poison glands and a toxalbumen which exists everywhere throughout the whole body of a spider, especially in the legs and the eggs. (Dr. Coleman was able, it will be remembered, to kill a rabbit in two and one-half minutes and a cat in three minutes by injecting a solution derived from macerating the eggs of Latrodectes.) The more of the toxalbumen which penetrates the wound, so much the stronger, according to Kobert, are the general poisonous effects. While the more of the actual secretion of the poison

glands which goes into the wound, so much the stronger are the local effects, especially in the case of species of Latrodectes, which "produce by their bite," says Kobert, "the most serious general results, and are capable of killing even men." The secretion of the poison glands may be made more dangerous by far by its mixture with the toxalbumen of the general body. In the case of the diadem spider, Sachs found that while only local irritating results are produced by its bite, it possesses also in its body a toxalbumen analogous to that determined by Kobert for the Latrodectes, which, however, does not form part of the secretion of the poison glands. In the light of this fact, Sachs holds it to be very probable that the hemolytic results described by him are practically identical with the results referred by Kobert to toxalbumen.

Kobert describes the hemolytic working of both Latrodectes and diadem spider poison. He found the hemolytic effects of the latter to be real, but much less in degree than that of the Latrodectes poison. Kobert found the Latrodectes poison to be effective on dog blood which was one of the kinds of blood which Sachs found to be practically immune to diadem poison, so that perhaps the Latrodectes poison would be found to be even more serious in the case of those kinds of blood which Sachs found to be affected by the diadem spider's poison. Kobert also determined that a certain immunity or an acclimatization to Latrodectes poison as well as to diadem poison, can be brought about.

The results of the careful work of Sachs and Kobert prove conclusively the active and formidable character of spider poison. In ordinary biting by spiders, a very small quantity of poison finds it way into the wound; not enough to trouble, in most cases, a human being. But with Latrodectes the poison seems more effective. A small amount injected by a single bite can threaten the life of a man. Probably with Latrodectes, as with other animal poisons, the physiological idiosyncrasies of the particular man bitten play an important part in determining the degree of seriousness of the trouble produced. Some of us are badly injured by a bee's sting; most of us are not. To most of us a rattlesnake's bite would be serious; to a few of us, it would not be. I can believe that the bite of Latrodectes would not be serious to certain men; I must believe that it can be serious to some; for it has been.

SARCOSPORIDIA ENCOUNTERED IN PANAMA

S. T. Darling

From Board of Health Laboratories, Ancon, Canal Zone.

During the routine examination of nearly one thousand animals that have come to autopsy here and have been specially examined for parasites, Sarcosporidia have been detected in three new hosts: opossum,[1] hawk and sloth. The following animals were also found to be parasitized: horse, cow, hog, sheep, cat, man[2] and rat, *Mus. rattus* and *Mus. norvegicus*.[2]

Most of the sarcocysts of the common species were found to resemble closely those described from these animals by other writers. The sarcocyst of man, however, presented a different appearance from the one described by Baraban and St. Remy from the laryngeal muscles of man in that the former exhibited younger and apparently abortive cysts. Sarcosporidiosis appears to be far more widespread among various animals than has been supposed. Some host species appear to show a constantly high incidence of infection; others, as man, for example, seem rarely infected.

The infection is a common one, but it probably has little pathological significance or economic importance. It is extremely rare here to find an animal other than a rat visibly infected and those sarcocysts encountered microscopically display little or no evidence of having induced any tissue reaction.

Some animals retain permanently evidences of the infection, but my observations in a case of infection[2] of a negro lead me to believe that sarcocysts may be abortive and after a short residence in the muscle fibers disappear in various ways.

Interest in Sarcosporidia centers in their life cycle, and considering the large number of infected animals accessible for experimentation, it is remarkable that so little light has been thrown on the subject. This is very largely due, no doubt, to the view that the sarcocysts are not pathogenic[3] and are of doubtful economic importance.

Sarcosporidia of birds have been described by Kühn, Leidy, Rivolta, Barrows and Stiles,[4] the following birds having been parasitized: com-

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1. Bull. de la Soc. Path. Exot., iii, p. 513, 1910.
2. Arch. Int. Med., April, 1909.
3. McGowan: Investigation into the disease of sheep called "Scrapie." Blackwood, Edinburgh, 1914, p. 116, believes that "Scrapie" is due to Sarcosporidiasis.
4. See Bull. No. 3, B. A. I., U. S. Dept. of Agr., 1893.

mon fowl, *Gallus,* blackbird, raven, shoveler, spoonbill duck, mallard duck, grosbeak, and two Brazilian birds, *Aramadis saracura* and *Ammodromus manimbe.*[5]

SARCOCYST OF THE HAWK: *Leucopternis* SP.

The sarcocysts were detected microscopically and had invaded the striated muscles of the leg, and presumably elsewhere. The muscle fibers of smaller size were usually invaded, for the sarcocysts in cross section were 29 and 20 μ in diameter, while the diameter of the muscle fibers nearby was only 16 μ.

Muscle fibers of larger size were also parasitized for one sarcocyst was 48 μ in diameter with a limiting membrane or false capsule of muscle substance 6 μ in thickness. This was not striated and was of lighter color than neighboring muscle fibers which were 32 μ to 44 μ in diameter (Figs. 3 and 4).

The sporozoites were 4.5 μ long and 1.2 to 1.5 μ wide with a nucleus in one end apparently about 1.0 μ in diameter. The sporozoite stains rather diffusedly with hematoxylin. A definite reticulum cannot be made out, but there are clear spaces within the sarcocyst indicating the presence of sporoblastic chambers.

A few small parasites 12 μ in diameter have invaded the muscle fibers of the heart and here they have a thin but definite limiting capsule and are located in the inner circular layer. None was seen in the outer longitudinal layer of fibers.

SARCOCYST OF THE SLOTH

The tissues of this animal *Cholocpus didactylus* as well as of several other individuals were searched for sarcocysts, but not until a microscopic examination of sections of muscle was made were any found, the sarcocysts being found in the esophagus and muscles of limbs and trunk.

The sarcocysts were always found within the muscle fiber enclosed in a very thin capsule. One sarcocyst measured 0.033 mm. in diameter, its muscle fiber being 0.051 mm. in diameter. Another occupied the entire width of the muscle fiber. The muscle of the esophagus was more highly infected than other muscles and the sarcocysts were more frequently found in its middle longitudinal layer of fibers.

None was found in the heart. Not all the sections of muscle examined were parasitized, however, and none was found in viscera examined: kidneys, lymph nodes, spleen, liver and lungs. In the infected muscle the sarcocysts were packed with sporozoites or sporoblasts, which were either banana-shaped or round. Isolated spores were

5. See Splendore, Rev. d. Soc. de São Paulo, pp. 115-120, 1907.

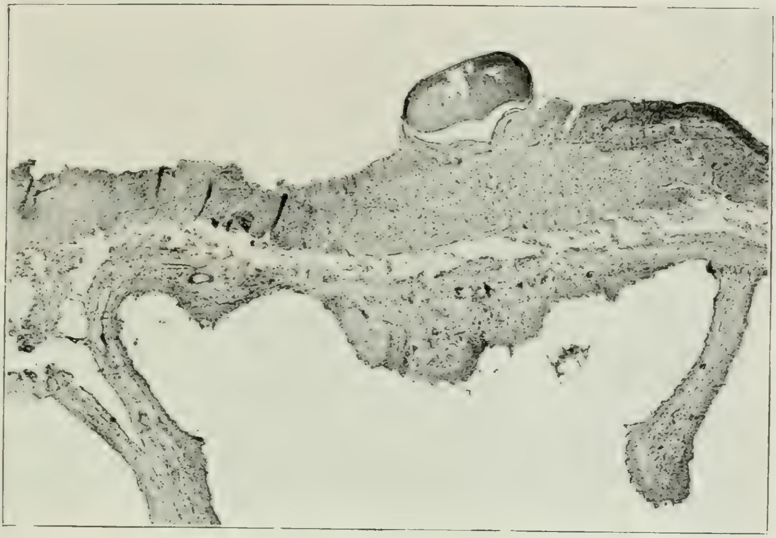

Fig. 1

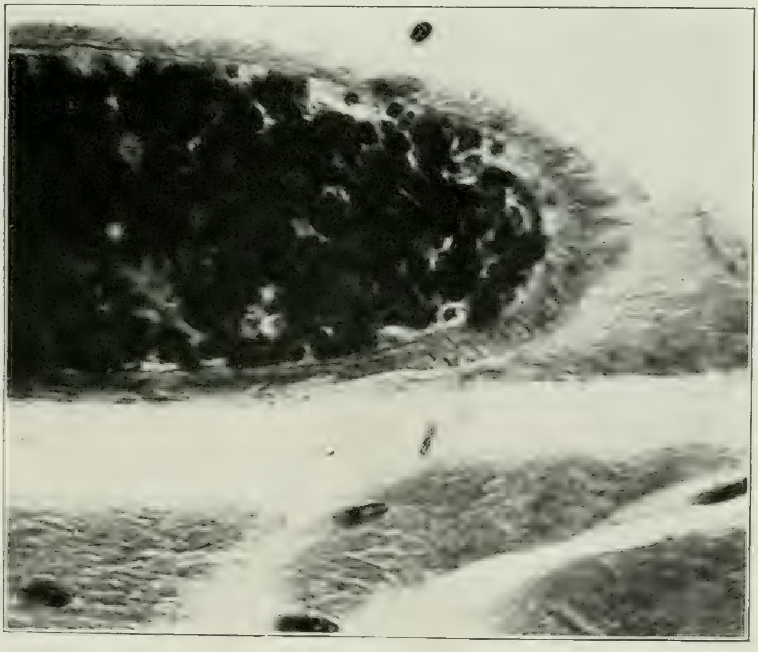

Fig. 2

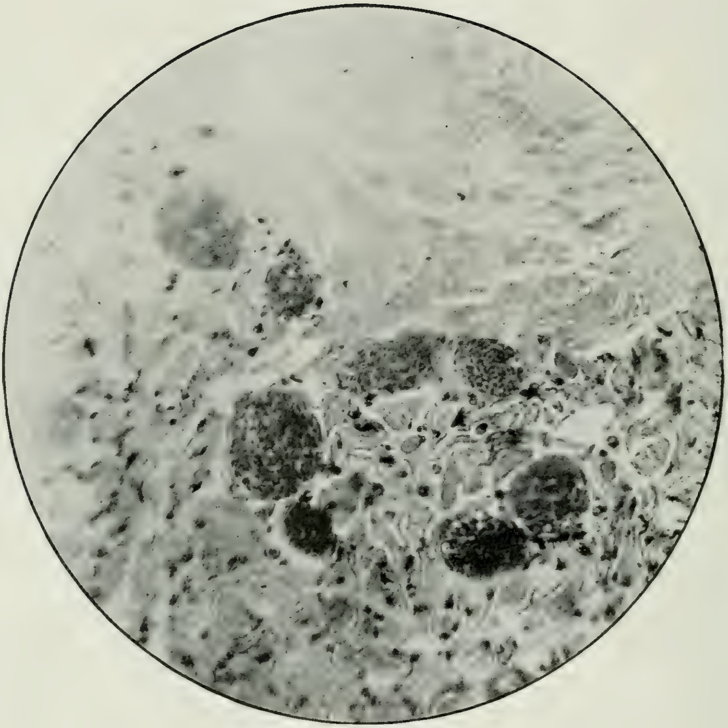

Fig. 3

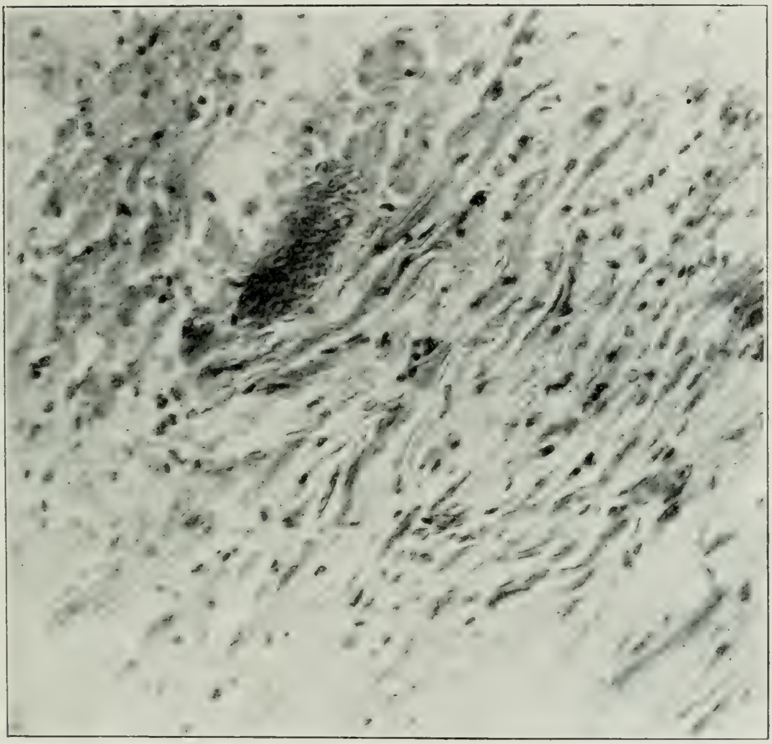

Fig. 4

Fig. 5

examined with difficulty on account of their being so closely packed together in the cyst.

Altogether the sarcocysts resembled those seen in man, opossum, and guinea-pig experimentally infected with *S. muris*. Apparently, there are two well-marked types of sarcocysts, those with large sporoblasts seen in rat, sheep, cattle and horse, and the type with very small sporozoites or sporoblasts encountered in man, sloth and opossum.

Considering the results of the experiments of Negri, and the writer, with "*S. muris*" as well as those of Erdmann with "*S. tenella*" in which there was a reduction in the size of the sporozoite encountered in the subinoculated animals it seems likely that the size of the sporozoites in the sarcocyst may depend on the host and be irrespective of the variety of sporozoite inoculated.

SARCOCYST OF THE OPOSSUM

This remarkable parasite was found in the opossum *Didelphis* sp. distributed to the voluntary muscles and heart and also in the lungs, stomach, small intestine (Fig. 1), and its mesentery, pericardium, submaxillary gland, and esophagus, but not in the kidney, liver, spleen, pancreas, bladder, gall-bladder, external genitalia, or eye and extrinsic muscles. For this reason the definition of Sarcosporidia must be amended to include representatives which from the very start lodge and develop in non-muscular tissue.

All the parasites were of one size and age.

The attempt was made to infect guinea-pigs by the intramuscular inoculation of sporozoites; and in one of two guinea-pigs so inoculated with the opossum parasite and sacrificed sixty days after inoculation, Sarcosporidia were found in sections of muscle from the leg inoculated. The other guinea-pig, when sacrificed after a period of 146 days failed to disclose parasites in tissue from either leg.

The Sarcosporidium found is believed to be of an abortive type and probably does not experience further development, but dies out early. The feeding habits of the host suggested at the time that the parasite might have been derived from poultry, and one out of a good many fowl examined, a black Orpington, contained lime-infiltrated bodies grossly not unlike the Sarcosporidia found in the opossum. While the rat, cat, hawk and other animals revealed Sarcocysts of different ages, in the opossum they were all of one age. Apparently there had been but one infecting period and no auto-infection as described by Negri in other forms.

SARCOSPORIDIA OF THE CAT

Wasielewski[6] states that Sarcosporidia have been found in the domestic cat, and Railliet[7] quotes Krause as having discovered these parasites in the ocular muscles of the cat.

A vagrant cat, much emaciated and dying of starvation, was caught near the laboratory. After being chloroformed it was noted that a large chicken bone had become wedged between the back teeth effectually preventing the use of the jaw. There was found a severe itch mite dermatitis of both ears and a number of intestinal cestodes and nematodes.

No gross evidences of sarcosporidiosis were noted at autopsy, but from the size of some of the parasites detected later in sections of tissue the infection must have been visible macroscopically if the muscle had been more carefully scrutinized.

Microscopically, there was extreme atrophy of the spleen and vacuolar degeneration of renal epithelium as in starvation. Striated muscle contained many parasites 24 to 160 μ in diameter, the normal muscle fibers nearby being 24 to 40 μ in diameter. There was an extremely delicate limiting membrane with delicate prolongations suggestive of sporoblastic chambers. The muscle substance enclosing the parasite was paler in color and more refractile and granular than neighboring muscle. In the larger parasite the sporozoites or sporoblasts were in agglomerated masses.

A few very young parasites were seen containing sporoblasts (Fig. 5) very much like those of *S. tenella* and there was no limiting membrane or capsule visible. The sporozoite in sections appears to be about 7.5 μ by 1.5 μ.

SARCOCYST OF MAN

This was detected during life in the biceps of a young negro.[2] Examination disclosed small sarcocysts one-third to one-half the diameter of the muscle fiber, distended with vesicular sporoblasts. The parasite was of the minute or abortive type such as Negri and I have found in guinea-pigs fed with sarcocysts from the rat and differed from those described from the laryngeal muscle of a man by Baraban and St. Remy in that the latter were much larger, possessed sporoblastic chambers, and were of a more mature type. Four months after the parasite had been detected, another examination of tissue showed that apparently they had entirely disappeared.

SARCOCYSTIS MURIS

This form was frequently encountered during the routine bacteriological examination of rats from Panama and the Canal Zone. The

6. Wasielewski, Sporozoenkunde, Jena, 1896, p. 119.
7. Railliet, Zool. Médic. et Afric., 1895, p. 154.

young and immature rats usually showed no signs of gross infection, but when muscle was examined microscopically small sarcocysts were sometimes detected. Out of 131 adult rats examined grossly, 15 or 11.4 per cent. were infected. *Mus norvegicus* showed a higher percentage of infection (10.7 per cent.) than *M. rattus* (3.5 per cent.). There was never the slightest indication of cellular proliferation or necrosis in the muscle fiber of the infected rats and the animals all appeared to be in good physical condition.

Feeding experiments were carried out with *S. muris* on guinea-pigs. Four pigs proved negative upon microscopic examination of several blocks of muscular tissue, but after a period of 164 days Sarcosporidia were detected in sections of muscle from two guinea-pigs; the morphology, however, was different from that of the sporozoites fed from the rats in that the former were much smaller and resembled those seen in tissue from the biceps of the human case and in guinea-pigs inoculated intramuscularly with sporozoites from the sarcocysts of an opossum.

SARCOCYSTIS TENELLA

There are no sheep in Panama. Occasionally a lamb is brought in from Peru to be kept as a pet, but for some reason they do very poorly. One such lamb died and was examined at the laboratory. At the autopsy there was a slight amount of pericardial clear fluid, general glandular enlargement and splenization of the lungs. Microscopically, there were many epithelial necroses in the kidneys and a few small Sarcosporidia in muscle fibers of the esophagus 22.5 μ in diameter. These were very young parasite and corresponded to the description of *S. tenella* (see Railliet).

SARCOCYSTIS MIESCHERIANA

During a histological examination of hogs that had died of swine fever, sarcocysts were detected in striated muscle. The hogs were red Jersey, Berkshires and natives, and were bred in Panama. They contained young parasites with very large sporoblasts 3 by 8 μ or larger in sections.

SARCOCYSTIS FUSIFORMIS

Case 1. Material was obtained from an emaciated cow of the hospital dairy herd originally from the U. S. A., that had died of puerperal pyemia. Some large sarcocysts were seen in striated muscle. The muscle fiber enclosing the parasite was altered into two layers, an inner dark or granular layer and an outer paler layer, paler than the muscle nearby (Fig. 2). The sporozoites are very large and apparently packed in room systems.

Case 2. Emaciated cow, from the Ancon dairy herd, originally from the U. S. A. The autopsy findings were bronchial strongyles, liver necrosis and aneurysm of hepatic artery. The esophagus contains some large sized sarcocysts with a definite thin inner lining and a thicker grayish eosin colored capsule with radiating striations (see figure as in *S. tenella*). There is a delicate eosin staining reticulum making the room systems (sporoblastic chamber or capsule).

This sarcosporidian has also been detected in muscle tissue of beef from Argentina.

SARCOCYSTIS BERTRAMI

An emaciated mule from the U. S. A., 14 years old, died suddenly without assignable cause of death. Sarcocysts with large sporozoites 3 by 9 μ with eosin staining cytoplasm were detected in striated muscle.

DISCUSSION

The deepest mystery surrounds the life history of the Sarcosporidia. Minchin says that in the present state of our knowledge the Sarcosporidia would appear to be true Cnidosporidia with spores which contain each a single polar capsule and from which an amebula is liberated as in other Neosporidia.

Theobald Smith[8] succeeded in infecting mice by feeding muscle tissue of infected mice to non-infected animals, and while cannibalism and carnivorous habits may spread the infection among certain animals it is certainly not the way the disease is transmitted to sheep and cattle. Watson, according to Minchin, stated that spores are to be found in the circulating blood, but McGowan believes that Watson was very indefinite on the subject and his remarks may not bear that interpretation.

In attempting to account for the Sarcosporidium of cattle Smith states "their muscle parasite is either an aberrant form from some invertebrate taken in with their food or else there is an intestinal stage . . ." Professor Smith further states that he desists "from any further discussion not based on actual studies."

According to Minchin,[9] who follows Erdmann, the spores germinate in the intestines of the new host. There is a liberation of sarcotoxin which destroys the epithelium. Amebulae are set free which penetrate into lymph spaces of the submucous coat. By analogy this represents the planont or first stage, it is initiated by sexual processes.

The second stage represents invasion of muscle fibers and development of amebulae therein, first by a multiplication of nuclei until about twelve nuclei are seen. The parasite becomes divided up into separate cells or pansporoblasts or sporonts which actively multiply by division. This stage is reached in forty-eight to sixty days. The

8. Smith, Jour. of Exp. Med., vi, 1901.
9. Minchin: An Introduction to the Study of the Protozoa, 1912, p. 422.

parasite may disintegrate at this stage setting free sporonts or may develop into a Miescher's tube. If the former, there is wandering out and invading other muscle cells; in the latter development of an enclosing membrane with chambers occurs. Fully formed spores are found in parasites eighty to ninety days after the infection of the host.

Thus, Sarcosporidia belong to a group of sporozoa, the *Neosporidia,* which often occur in invertebrates as in the larva of the silk-worm moth, and the mode of infection is contaminative, i. e., by ingestion of spores on leaves and by an hereditary way in which ova are infected.

Fantham and Porter,[10] in an investigation of the pathogenicity of *Nosema apis* to insects other than hive bees, found that humble bees, mason bees and wasps became infected.

Cabbage plants near a badly diseased hive were found spattered with bee excrement. Dead larvae of cabbage-white butterflies also were found, whereupon it was ascertained that when this larva was fed on spore-infected honey-cabbage the larva became infected and diseased.

Cinnabar and gooseberry moths were infected experimentally. Blowflies, craneflies and sheep keds were also infected experimentally. This investigation of Fantham and Porter's indicates that *Nosema* is capable of causing infection and disease in quite a range of invertebrate hosts and the wideness of the range suggests the possibility that vertebrates might be as easily infected.

The animals most highly infected with Sarcosporidia, i. e., high incidence of infection, are pigs, sheep, cattle and horses, i. e., non-flesh-eating animals. If Sarcosporidia are obligate parasites for mammals and other vertebrates, the contaminative mode of infection from mammalian and vertebrate hosts seems to be out of the question, for the spores cannot be liberated from the muscles, and, so far as we know, do not escape by way of the intestinal tract of the host to infect his environment; nor is it likely that they get into the blood stream.

In the case of mice, rats and carnivorous animals the mode of infection may in part be by way of the intestinal tract through eating infected tissue; but the infection of sheep, cattle and horses cannot be explained in this way.

On account of the facility with which herbivora may obtain and ingest invertebrates infected with Neosporidia, but more particularly flowers, leaves, etc., or water contaminated with droppings of bees, moth larvae, fly droppings, etc., or other material containing Neosporidia spores, is it not possible that Sarcosporidia may be sidetracked varieties of some of the Neosporidia of invertebrates which have invaded the musculature of a hospitable though by no means definitive host and are unable to continue further their life cycle and escape from

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10. Ann. Trop. Med. and Paras., vii, 1913, p. 569.

a compromising and aberrant position? The strikingly high incidence of infection among hogs, cattle, sheep and horses might be explained in this way.

While many parasites are obligate in their host relationships there can be no doubt but that certain protozoa, usually parasitic in invertebrates, may more or less readily succeed in establishing a foot-hold in the tissues of man or other mammal and cause a definite pathological condition therein. Take dermal leishmaniasis for example. In 1910 a solitary cases of this disease was detected here in a man that had been bitten by a tabanid fly out in the bush. Since that date some five or six others have been identified here by the presence of intracellular parasites morphologically identical with *L. tropica*. Now, if *L. tropica* is an obligate specific parasite for man, it is very unlikely that Tabanids or other biting flies are carrying it about in the Canal Zone and only half a dozen cases arise in as many years. At the[11] time I suggested that the sore was the result of an infection by an insect flagellate, and the subsequent incidence of the disease now emphasizes the importance of this view very strongly.

Considering the infrequency of dermal leishmaniasis in this region, the sparseness of the parasites in many of the ulcers and the extreme unlikelihood of an insect being able to penetrate the tough crust of the ulcer or of the papule to regain the flagellate and carry it on, it seems unlikely, assuming that there is a specific form of the virus of oriental sore, that it could be propagated in a region without our being able to detect many more examples of it if it were necessary for its life cycle to be carried out in an insect as well as man.

Under the circumstances it is far more probable that the dermal leishmaniasis of Panama at any rate is "a disease caused by the inoculation of one or more varieties of insect flagellates."

If this should prove to be true then the parasites in the sore are permanently sidetracked in the tissues of man and have no natural way of continuing their life cycle in the variety of insect from which they originally came. It is possible that other protozoa, and among them Neosporidia, meet with similar fates, the latter becoming sidetracked in the muscle fibers as "sarcosporidia" (as well as in other tissues occasionally, such as that of opossum and kangaroo) and while attempting blindly to continue their life cycle in their vertebrate host have no further opportunities for completing the same.

Experiments with *Nosema* or other *Neosporidia* would settle the matter at once, and I regret that no material has been encountered here with which these views on the probable zoologic status of Sarcosporidia might be tested.

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11. Darling: Arch. Int. Med., Chicago, 1911, vii, p. 581. Proc. Soc. Trop. Med. and Hygiene, Lond., 1910, iv, No. 2, p. 60.

OTACARIASIS IN THE BIGHORN *

HENRY B. WARD

In March, 1914, Mr. G. H. Thomson, superintendent of the Estes Park Fish Hatchery, Colorado, sent me a vial containing some material he had taken from a mountain sheep the previous December. Concerning the material, Mr. Thomson wrote as follows:

> Last December we had a very severe fall of snow so that there was five feet on the level, which made it next to impossible to get around, and which made it exceptionally hard on our wild game. I found a two-year-old mountain sheep that had been separated from the bunch by a mountain lion and was tired out in the deep snow; with the help of others I got it on my horse and brought it home with me, and have had it since that time. It has been very interesting but some time after I had it here I found that it had some trouble with its ears from scaling off and the hair came out on its head; I treated it with vaselin and liniment which seemed to help it but the affection seemed to come from its ears on the inside. They would scale off down deep in the ears and block up its passage; I have opened them and have examined them very closely but could not find out the trouble. I have examined the scale under a heavy glass but even then failed to find the trouble; but this morning a portion of the scale looked different than usual as it came from deep down in the ears and upon examining it very closely I found that it was filled with a parasite. There did not seem to be any life in them, but when I warmed them up a little it was simply a mass of life. I am sending you a sample of the scale and also the scales with the parasites upon them and trust that they may reach you in life.
>
> I should like very much to know what they are and also what the final effect would be on the sheep if it was upon the mountain side where it could have no attention. The sheep is doing well and eats well both hay and grain and also potato parings and most everything that I give him.

May 18 Mr. Thomson wrote again in reply to my inquiries, as follows:

> From close observation of the sheep on the mountain side with a good glass there are not many that are affected, or if so not so badly as the sheep I had.
>
> I used a strong solution of carbolic acid and olive oil on the inside of the ear and cleaned them out so the ear cleared up, and it was that way for some time but they came back later and I had to treat it again. I then sent it to the City Park at Denver so I have not been able to follow it lately.

The specimens arrived in good condition and were observed living for some time. Even at the first glance it was possible to determine it as a mite of the group known as Itch or Scab Mites, the Sarcoptidae. A study of both living and preserved material was made to determine more exactly the structure and relationship of the form.

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* Contributions from the Zoological Laboratory of the University of Illinois, No. 40.

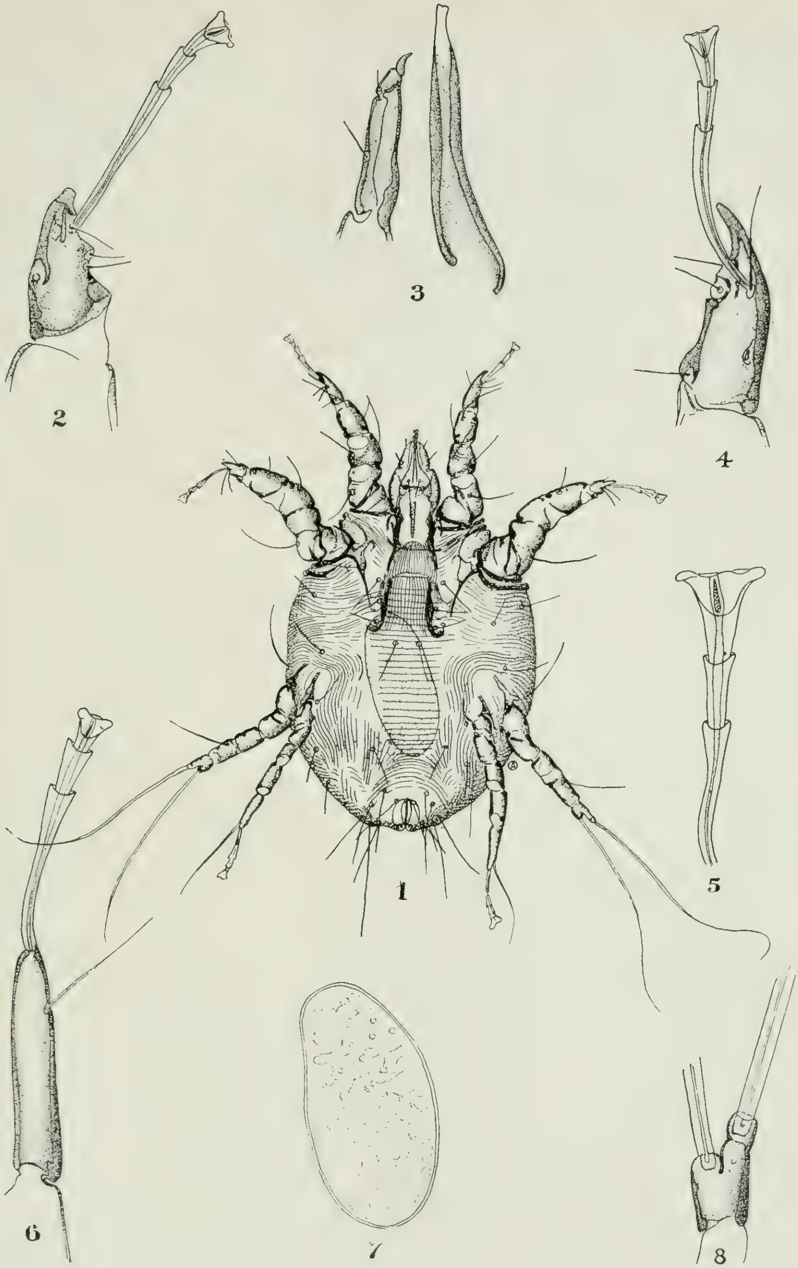
The full-grown ovigerous female (Fig. 1) measured from 680 to 750 microns in length and 425 to 545 microns in breadth; its average dimensions were 720 by 460 microns. Young females were 500 to 580 microns long by 390 to 440 microns wide, or on the average 535 by 410 microns. The male measured 490 to 570 microns long by 325 to 390 microns in width, with an average of 515 by 550 microns. The eggs measured varied from 275 to 355 microns in length by 120 to 220 microns in width; the average of undistorted specimens was 330 by 195 microns.

The form of the appendages can be most easily described by reference to the illustrations, which were made from camera drawings. Characteristic are the jointed stalked suckers (Fig. 5) that terminate the first, second, and fourth pairs of legs in the female (Figs. 2, 4, 6), whereas the third pair ends in two long slender bristles (Fig. 8). The mouth parts (Fig. 3) are apparently peculiar to this form and differ from any figured for species previously known in the genus. One can readily determine the numbers and location of the fine bristles occurring on each joint of each appendage, and also on the various regions of the adult female, which is illustrated (Fig. 1).

The male, which is not illustrated here, has two well-developed caudal lobes carrying long stout bristles. There is a conspicuous sucking disk at the base of each caudal lobe alongside the anal orifice.

As a rule, authors have sought to differentiate species by more conspicuous details of structure and by the type of scab produced while the varieties were named after the host on which the form occurred. In general, very few species have been recognized, sometimes only a single one, but with many varieties in a genus. Ability to transfer the parasite experimentally from one host to another has also been accepted as a measure of relationship, and those forms which cannot be transferred have been elevated from varietal to specific rank. Such physiological data are of great interest, but can hardly be accepted as adequate evidence of systematic position. When more exact anatomical descriptions have been written and utilized to differentiate the species, one can hardly doubt that some will prove to have adapted themselves under experiment to several hosts, and others will be shown to be exclusive in habit.

If now one seeks to find morphological data to distinguish species, it must be confessed that the descriptions given of the different species and varieties of these mites are unfortunately inadequate for accurate determination. For the most part the details cited by various authors are limited to the size of individuals of various ages and sexes; but these vary rather widely, even at the same stage of development, and the different varieties overlap in size so much that one might place a



EXPLANATION OF PLATE

Camera drawings of *Psoroptes cervinae* nov. sp.

Fig. 1.—Ovigerous female in ventral aspect. X 59.
Fig. 2.—Distal joints of leg II. X 350.
Fig. 3.—Mandible and palp. X 350.
Fig. 4.—Distal joint of leg I. X 350.
Fig. 5.—Jointed stalked sucker. X 590.
Fig. 6.—Distal joint of leg IV. X 350
Fig. 7.—Egg. X 120.
Fig. 8.—Distal joint of leg III. X 350.

given form in any one of two or three groups if that evidence alone were relied on.

Many of the figures given by different authors are admirable, and even a superficial examination of them discloses differences in the form, size and armature of various appendages, such as are clearly adequate for the differentiation of the species. But in the text accompanying the illustrations these items are neither described nor compared sufficiently precisely to enable others to utilize the data for the determination of species. This is not the place to enter upon an extended discussion of these details. The latest monographic revisions of the sarcoptids leave much undecided and vague regarding the species, and until a further study is made of a large series of forms one can only arrive at a partial conclusion regarding supposed new material.

The form under consideration unquestionably belongs to the genus Psoroptes, as it is described by Canestrini and Kramer (1899). These authors recognize only five species and confess that these are not well defined. The species are all named from their hosts; three *Ps. bovis, Ps. equi* and *Ps. ovis* produce the psoroptic scab well known on these hosts; *Ps. cuniculi* gives rise to auricular scab in rabbits; *Ps. gazellae* is extremely briefly described, and no data as to its origin and hosts or the disease produced are given at all. To these species must be added *Ps. caprae*, described by Railliet (1893). While the data given for the species are few, it seems that both because of size and because of the type of scab produced the form under consideration cannot be placed in any one of the first three species. It differs also too clearly from the species reported from the rabbit to be included in that even tho the type of the scab is the same. The measurements show the Colorado form is very much like *Ps. gazellae* and *Ps. caprae,* but the data given are so extremely scanty that one would be subject to criticism for basing any final decision on such incomplete evidence.

A comparison of the figures given by various authors to illustrate the species might be used to supplement the few general measurements they have recorded. The form from Colorado appears at once to be clearly differentiated from any other species which is figured. These differences are indicated by comparing the figure given here with those of Psoroptes given by Mégnin. Unfortunately for the purpose, all his illustrations seem to be made from the form found on the horse, which was formerly designated the typical variety of the single species in the genus, but is now regarded as one of the several distinct species. On comparison with this, the Colorado form appears to have a rostrum materially shorter and broader than in *Ps. equi,* designated *longirostris* by Mégnin; the proportions of the appendages do not agree with those in *Ps. equi,* and the stalked suckers are distinctly shorter as well as

apparently more slender in the Colorado form. Moreover, the shape of the body is not the same in figures of the two species. While these are apparently minor discrepancies, I consider them adequate to justify fully the separation of these forms as distinct species.

Unfortunately, no figures at all have been published for the species which in size most closely approximate this form. Of *Ps. gazellae* the describer (Canestrini, 1894) gives only scanty data regarding its general size. He says, further, that it is very similar in size to *Ps. equi* and in the type of scab that it produces to *Ps. cuniculi*. No data are furnished concerning the origin, geographical distribution, hosts or effects. To diagnose a species on this description would be venturesome.

Railliet (1893) has given a more extended description of *Ps. caprae* by referring to the records of other authors. His remark that an analogous observation was made by Ugo Caparini on a gazelle very likely refers to the material which was the basis of Canestrini's description of *Ps. gazellae*. But here again precise evidence is wanting to determine whether the Colorado form belongs in this species, of which more is said later in this paper. I am of the opinion that these two (*Ps. caprae* and *Ps. gazellae*) are the same species, and indeed it is impossible from the data given to separate them save by the hosts, which is an unreliable method. Yet it would certainly introduce even greater confusion than now exists to assign the Colorado form to either species in the light of the present scanty knowledge concerning both. The wide geographic separation of these hosts and the inadequate evidence on which to base a demonstration of the identity of the parasites together with the structural peculiarities of the Colorado form compel me to list the latter as a new species for which I suggest the name *Psoroptes cervinae*.

Ear scab, or otacariasis as it has been appropriately designated by Neumann, is not a frequent complaint but scattered references to such trouble are found in the literature. In 1834 Hering found a mite in the dog's ear; since then it has been discovered in the same and other hosts and renamed many times. It seems to be fairly common in dog, cat, and ferret in Europe. Many observers have commented on the severe epileptic attacks to which the infected animals are subject. These are especially sudden and violent among hunting dogs engaged in the chase.

This form lacks the caudal lobes on the abdomen of the male and has been made into a separate genus, now designated Otodectes, of which at least two species are known, *O. cynotis* Hering and *O. furonis* Railliet. Banks (1904:99) says that the first species has been taken in this country. These species are both so distinct from the Colorado form discussed here that confusion is unlikely.

The Colorado form is also a very different mite from that reported by Leidy (1872) which was found in the ear of an ox.* That form belongs to the Gamasidae or beetle mites, whereas the species under consideration here is grouped with the Sarcoptidae, variously called scab mites or itch mites. To this group belongs different species that produce various types of itch or scab in man and other higher animals. Many of those that frequent other hosts are transferable under circumstances to man and produce on this host a type of itch which may be temporary and relatively insignificant or on the other hand lasting and difficult to eliminate. It is not known that any form of ear itch can be transferred to man.

Auricular psoroptic scab, or psoroptic otacariasis, has been known in Europe where it was first reported by Pezas from the wild goat of the Pyrenees. The cause of the trouble was recognized as a mite in the external auditory meatus and the species was identified as *Psoroptes communis* var. *caprae*. The determination was confirmed by Pench and Neumann and in a second case by Mégnin and Railliet. Otacariasis was also observed in the Congo by Mense who regarded the cause as a special form of Psoroptes to which he gave the name of *P. congolensis*. However, Gedoelst (1909) has shown that the Congo form is the same species of mite as that which gives rise to the disease in the goats of the Pyrenees, or at most in his opinion a closely related variety. Mense reported that the goats became deaf, refused to eat, and in a few months perished. According to all these authors the malady is serious, and the prognosis grave unless the trouble receives immediate attention. This is naturally excluded whenever the trouble appears among wild animals and in the case of such the disease will necessarily run its course unhindered.

The only mention I have found of scab on the mountain sheep of Colorado is printed by Warren (1906:238) who writes in his section on the Bighorn as follows:

"C. F. Frey tells me they suffer much from scab in the West Elk Mountains and that a party told him in 1901, at one place near the head of Sapinero Creek seventy-five head were counted which had died of scab. Domestic sheep have been seen in that locality, and the wild sheep doubtless contracted it from them."

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* In this connection I may correct a misstatement of Freund (1910), who says that Trouessart is in error, as all others before him, in citing the name of this species as *Gamasus auris* Leidy and that Leidy never used the specific name *auris*. To be sure Leidy did not employ that name on his first note (1872: 9) read at the January meeting of the Philadelphia Academy, but did in his supplementary reference (1872: 138) made at the June meeting. Evidently Freund did not see the original of Leidy as he cites the pages incorrectly as well as misstates the facts regarding the text. Leidy both described and named the ox ear mite.

This is not the same complaint as the one described in this paper, but is that well known among domesticated sheep and designated usually as common sheep scab. Salmon and Stiles (1898) have given an extended account of that disease. It is highly contagious and probably easily transmitted to susceptible wild species by means of wool, scab, etc., scattered over the range. Treatment is essential and very few animals make a spontaneous recovery. So far as has been ascertained no observer has recorded auricular scab, or any trouble caused by a different species. Hall (1912) states he found the common scab mite of sheep on a mountain sheep, *Ovis nelsoni,* which was suffering from scab in the National Zoological Park, Washington, D. C. No statement is made concerning the source of this infection. Since neither Salmon and Stiles, nor so far as I have ascertained any later author refers to auricular psoroptic scab, I am led to believe that it is at least uncommon among domestic sheep in this country. This accords with conditions abroad where its occurrence is noted only in the two regions named.

Finally a word on the general import of the trouble reported in this paper. It is stated on the one hand that mountain sheep still exist in the United States in sufficient numbers to assure their continued existence if reasonable laws are enforced—except for the danger of disease. On the other hand little or nothing is known of the types of disease prevalent among these animals or the range and severity of the various maladies. In Colorado the Bighorn is believed to be increasing in numbers and this if true renders them more likely to be visited in that region by epizootics of some sort. Prominent among such are diseases of parasitic origin and the importance of calling prompt attention to attacks of such diseases needs no special elucidation. This is the justification for publishing a brief discussion of such a malady as that which has been brought to my attention through the observations of Mr. Thomson.

SUMMARY

The ear of a mountain sheep at Estes Park, Colorado, was found to be heavily infested with a Sarcoptid mite which was not the common scab mite of domesticated sheep but is new in this country.

This form is similar to a mite found in the ear of goats in the Pyrenees and in the Congo. Nevertheless there is reason to consider it a new species and it is named *Psoroptes cervinae.*

The complaint to which it gives rise is likely to be serious if its effects are like those of the related European form. The Bighorn has been very greatly reduced in numbers by other causes and this malady merits the closest attention as a real menace to its host.

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TOCOTREMA LINGUA (CREPLIN)

THE ADULT STAGE OF A SKIN PARASITE OF THE CUNNER AND OTHER FISHES OF THE WOODS HOLE REGION *

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In 1884 John A. Ryder published an account of a skin parasite of the cunner (*Tautogolabrus adspersus*). The diseased fish which furnished the material for Ryder's paper were from two localities, Woods Hole, Mass., and Cape Breton, N. S., and had attracted the attention of collectors on account of a peculiar spotted and rough appearance due to the presence of cysts in the skin. While Ryder did not determine the exact nature of the animal inhabiting these cysts he concluded that it was most probably a flat worm belonging to the Trematoda.

In 1889 I noted the occurrence of similar cysts in the skin of a cunner (Linton, 1890). The appearance of the infected fish agreed with Ryder's description, and each cyst opened contained an immature trematode. Again I recorded (1901) the finding of this parasite in the tautog (*Tautoga onitis*). Since that date I have found this parasite on a number of the species of fish of the Woods Hole region. They are of frequent occurrence on the winter flounder, tomcod and eel, less so on other fishes, while cunners and tautog are seldom wholly free from them.

It was not until July 24, 1911, that an adult trematode was recognized as the final stage of the skin parasite. On that date I obtained from the intestine of the loon (*Gavia imber*) a large number of small distomes, 4,789 by actual count. Another loon was examined on September 1 of the same year with similar results. It was at once noticed that these trematodes bore a close resemblance to the immature forms occurring in the skin cysts of the cunner and other fishes of the region. A re-examination of some cysts from the skin of fishes was at once made, and the young forms liberated from the cysts compared with adults and immature from the intestine of the loon. Details of this examination are given later in this paper. It is sufficient to state in this place that enough points of resemblance were made out to warrant the conclusion that the trematodes found in the intestine of the loon are the adult stage of some, at least, of the immature encysted forms found in the skin of various fishes.

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* Contribution from U. S. Fisheries Biological Station, Woods Hole, Mass. Published by permission of Commissioner of Fisheries.

These small distomes from the loon appear to be identical with the species originally named *Distomum lingua* by Creplin, as that species is figured by Olsson, and the anatomy of the peculiar genital sucker agrees with that shown for this species in the excellent description and figures of Jaegerskiöld. Following is a description of the species based on my material.

Tocotrema lingua (*Creplin*) *Looss.*—Small, body depressed, margins, especially in the vicinity of the neck, with a tendency to fold ventrally; outline varying from linear to pyriform but mostly oval, tapering toward anterior end and bluntly rounded posteriorly; greatest breadth, in adults with eggs, at the level of the folds of the uterus, which is usually at about the posterior two-thirds of the length. The neck is from one-half to two-thirds of the entire length of the worm, depending on the state of contraction, and the outline varies accordingly. Young forms without ova may be nearly linear in outline or broader in front of the genital aperture than behind that structure. Very minute scale-like spines cover the anterior part of the body densely. These are plainly shown on the surface and margins in front of the genital aperture. Behind that point they are seen with difficulty. The acetabulum is minute, and forms an anterior, internal muscular portion of the genital sucker. The genital aperture is situated on the median line, from the middle of the length to the posterior two-thirds, according to the condition of contraction of the neck.

The oral sucker is subterminal and its aperture is circular. There is a very short prepharynx followed by the pharynx which is longer than broad, oval-elliptical, its length about equaling the diameter of the oral sucker. The slender esophagus is longer than the pharynx and may be more than twice as long. The forks of the intestine are slender, simple, and extend to the posterior end of the body.

Near the posterior end of the body are the two testes which are contiguous, diagonally placed, and, as seen in compressed specimens, distinctly lobed. In uncompressed individuals the lobes of the testes are often indistinct. The vas deferens is obscured by the folds of the uterus so that its course is difficult to trace. In a few specimens, which had a smaller number of ova than are found in most cases, a tubular seminal vesicle could be made out lying in a few loose folds dorsally behind the genital sucker. It terminates in an ejaculatory duct which lies in the dorsal portion of a short, papillary cirrus-like body (kegelförmiges körper of Jaegerskiöld) and empties into a genital sinus on the anterior margin of the cirrus-like body. The latter is surrounded by the muscles of the genital sucker. At the anterior margin of the right testis lies the relatively large seminal receptacle. In some cases this is nearly circular in outline; in others it is oval with the longer

diameter transverse. In sections it is seen to extend from the dorsal to the ventral wall of the body, but in the whole mounts it is perhaps more clearly seen in dorsal than in ventral view.

Along the anterior margin of the seminal receptacle is the ovary, which may be in part obscured by the folds of the uterus. When the worm is flattened and the ova are not too numerous the ovary is seen to be distinctly lobed. The ovary, seminal receptacle and testes therefore are massed together near the posterior end of the body. The folds

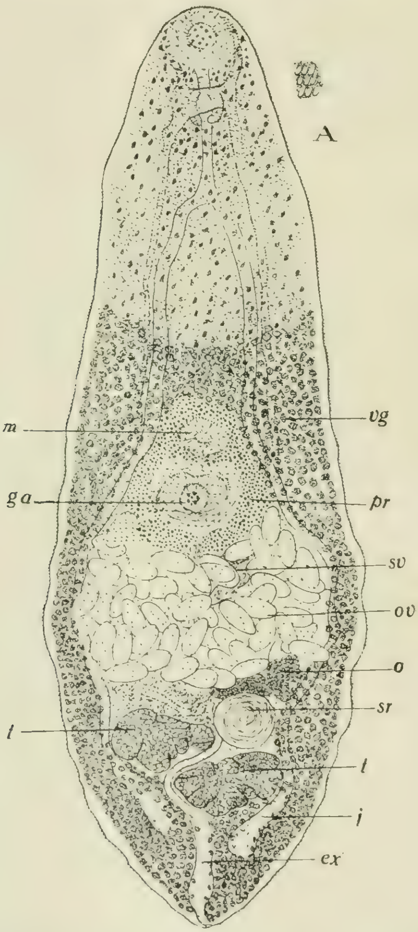

Fig. 1.—Adult specimen of Tocotrema lingua from Loon; dorsal view, in balsam. Length 0.84 mm. *a*, surface spines, 0.001 mm. long.

Abbreviations Used in Figures: *de*, ductus ejaculatorius; *ex*, excretory vessel; *ga*, genital aperture; *gp*, genital papilla; *gs*, genital sinus; *i*, intestine; *m*, ventral sucker; *o*, ovary; *ov*, ovum, ova in uterus; *pr*, prostate; *sr*, seminal receptacle; *sv*, seminal vesicle; *t*, testis; *v*, outlet of uterus; *vd*, vas deferens and seminal vesicle; *vg*, vitelline glands.

of the uterus are crowded between them and the genital aperture, the ova appearing as a golden yellow mass which extends nearly from margin to margin. The ova are oval-elliptical and, compared with the small size of the worm, are of good size. The terminal portion of the uterus opens into a cleft or sinus at a point adjacent to and dorsal to the opening of the ejaculatory duct. The genital sinus lies in front of the organ, called in the explanation of figures the genital papilla, (Figs. 4, 5, 6, *gp*), communicates anteriorly with the ventral sucker, and ventrally with the genital aperture. The genital sucker is surrounded

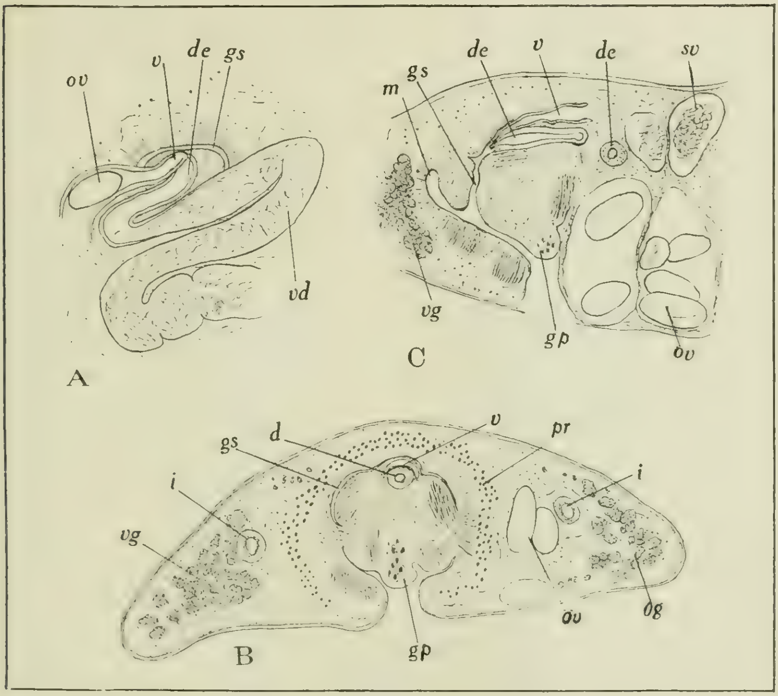

Fig. 2.—Sections thru dorsal portion of genital sucker; *A,* horizontal; *B,* transverse; *C,* sagittal.

by a somewhat triangular area of cells which are probably prostatic. The vitellaria are diffuse and fill the posterior and lateral margins of the body to a point in front of the genital aperture where they meet on the median line.

The excretory vessels were not completely made out. An excretory pore was distinguished situated dorsally at the posterior end of the body. From it a vessel was traced which passed between the testes. Transverse sections show a small lateral vessel on each side of the neck

region, but not distinctly enough to admit of satisfactory reconstruction.

A nerve mass lying dorsal to the pharynx, with short anterior branches, and lateral nerves traceable posteriorly to the anterior borders of the vitellaria are visible in many of the stained and mounted specimens.

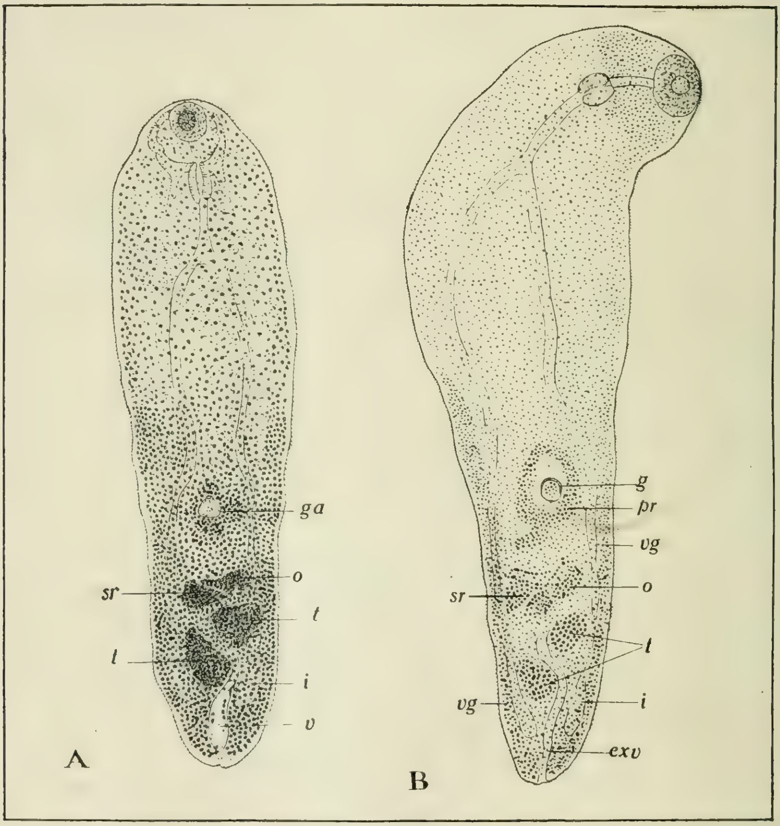

Fig. 3.—*A*. Young specimen from Loon; dorsal view, in balsam. Length 0.55 mm. *B*. Young distome from cyst in skin of cunner, in balsam. Length, 0.7 mm.

Dimensions of a living specimen in millimeters: Length 0.75; maximum breadth, 0.35; diameter of oral sucker, 0.07; ova, 0.04 by 0.02.

A specimen flattened under the cover-glass had the following dimensions: Length, 1.40; maximum breadth 0.70; diameter of oral sucker, 0.09; pharynx, length 0.04, breadth 0.03; ova, 0.047 by 0.023; genital sucker, 0.56 from the anterior end; bifurcation of the intestine

midway between anterior end and genital sucker. Following are lengths and breadths of ten specimens taken at random from a large number mounted in balsam:

Length,	0.70	0.97	0.76	0.80	0.55	0.80	0.76	0.67	0.72	0.64
Breadth	0.32	0.20	0.35	0.28	0.22	0.30	0.27	0.22	0.28	0.32

The above measurements were made of specimens from the loon. Following are dimensions of four specimens taken at random from a considerable number mounted in balsam, from the herring-gull:

Length	1.32	0.84	1.52	0.91
Breadth	0.40	0.33	0.48	0.33

Following is a record of the finds of *Tocotrema lingua* at Woods Hole. Some of these were made in 1904, but were not given special attention at the time of collecting.

Colymbus auritus: Feb. 8, 1912; 1.

Gavia imber: July 24, Sept. 1, 1911; very numerous on each date. Feb. 21, 1914, 2, immature.

Larus argentatus: Feb. 16, 17, 1912, numerous on each date. July 22, 1912, 252; Sept. 4, 1912, few. Jan. 22, 1914, 150; April 29, 1914, 1; Sept. 28, 1914, 1.

Larus atricilla: Aug. 12, 1904, 27 from one gull, 86 from another. Aug. 15, 1913, 18 from one gull, 6 from another.

Nyctocorax nictocorax: July 15, 1913; few, immature.

Sterna dougalli: Aug. 3, 1904, 1; Aug. 12, 1904, 21.

Sterna hirundo: Aug. 5, 1904, 1.

The specimens recorded for January and February are from the material collected by Vinal N. Edwards.

Young trematodes (Fig. 3B) from cysts taken from the skin of cunners, tautog, and other species of fish, were compared with specimens of *Tocotrema lingua* from the loon and other fish-eating birds with the following results: The body in each case was covered with a dense coat of minute scale-like spines of similar appearance; oral sucker, prepharynx, esophagus and intestinal rami agree; rudiments of genital sucker, genital papilla, testes, ovary, sperm receptacle and vitellaria agree in relative positions to the finished structures in the adult. Furthermore nothing was seen in the one that contradicted any point in the other.

A few immature specimens were found among the adults in the final hosts (Fig. 3A). These agree very closely in form with those removed from cysts in that the neck is wider than the posterior third of the body. With the maturing of the testes and ovary and the accumulation of ova in the uterus the posterior third becomes normally wider than the neck.

SUMMARY

Certain trematodes encysted in the skin of the fishes of the Woods Hole region are the young of an adult which lives in the intestine of the loon and other fish-eating birds.

The identification of these encysted distomes with *Tocotrema lingua* renders Stafford's name (*Dermocystis ctenolabri*) for these encysted forms inapplicable.

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THE HABITS, LIFE HISTORY, AND STRUCTURE OF A BLOOD-SUCKING MUSCID LARVA (*PROTOCALLIPHORA AZUREA*)*

Albert F. Coutant

While studying the blood parasites *Halteridium* and *Proteosoma,* and the *Filaria* of the common crow (*Corvus americana*), my attention was attracted by an external parasite of some young nestlings which were brought into the laboratory. Observations on this parasite, which proved to be the larva of *Protocalliphora azurea* (Fall.), form the basis of this paper. The parasite is the immature form of one of the so-called "blue-bottle" or flesh-flies, whose larvae are generally regarded as useful scavengers. More careful observations on the life-histories of many species, however, have shown that they may be, and often are, parasites of the higher animals.

The work was undertaken with the double purpose of seeking further knowledge of this parasitic habit of certain Sarcophagidae and of increasing the knowledge of the systematic characters in the group. It was carried on in the Entomological Laboratory of Cornell University under the direction of Prof. Wm. A. Riley, to whom I am gratefully indebted for continued suggestion and aid. I am also indebted to Prof. O. A. Johannsen, whose aid in the systematic part has been invaluable.

HABITS OF THE LARVA

On June 13, 1914, two young crows were brought to me. They were from the same nest and from comparison with others which I had reared, I judged them to be about five weeks old. They were put in a cage separate from my other crows, and seemed quite normal, save for fright. Three days later, however, one of them died and a post-mortem examination was made. Crawling among the feathers I discovered several larvae which looked in general like those of the Muscidae. They were from four to nine millimeters in length and were wriggling actively among the feathers, as if accustomed to this habitat. None were seen actually attached to the bird and feeding. The surface of their bodies was not a white or creamy color, as are the bodies of most of the blow-fly larvae, but was more the color of dirt. The contents of the alimentary canal showed through the skin dull-red, giving the whole larva a brownish-red appearance. Eleven

* Contribution from the Entomological Laboratory, Cornell University.

specimens were found on this bird. Most of them were among the feathers of the abdomen and were quite dry, but three were found in one ear cavity and were moist. The ventral part of the body of the crow had a number of small scab-like spots on it where the larvae had been feeding.

From the color of the alimentary canal of the larvae, I judged them to be blood-sucking, although this habit is not common in the larvae of this family. To test this I cut one in half and smeared the contents of the alimentary canal on a slide. Examination with the microscope proved conclusively that the alimentary canal was full of corpuscles of crow's blood. The crow, on further examination, proved to have died of malarial fever and there were enormous quantities of *Halteridium* in its erythrocytes. On discovering this I returned to the study of the blood from the larva's intestine, using an oil immersion lens, and thinking to find out whether the malarial parasites might become sexually mature here and give off the motile microgametes, as they do in the stomach of the Anopheles mosquito. I found no indication that this occurred.

Afterwards the floor of the cage under the straw was examined, and in the dirt I found forty or fifty more of the larvae, of various sizes and ages, crawling vigorously. All of them had more or less vertebrate blood in them, some of the larger ones having less than the smaller ones. From this I infer that the larvae are intermittent feeders, probably spending most of their time in nature in the dirt and more compact part of the bottom of the nest. The same day while feeding and holding in my hands the other crow from this nest, I observed one of the larvae clinging by its anterior end to the tibio-femoral joint of the crow's leg. Before I could examine it closer, the bird began to struggle and the larva released its hold; so I could not see the process of ingesting blood. Subsequently I placed larvae on my arm and in the hairs under the armpits, but they seemed very sensitive to handling and would not settle down to feeding. I made a number of attempts to rear the larvae on fresh and putrifying meat, flesh and liver of the crow, and beef. All of these experiments resulted negatively, except that one larva lived to pupate and died in this stage.

On the same day the larvae were found, I secured two young chicks of about the same development and allowed two maggots to crawl into each ear cavity, making eight larvae in all. They seemed to irritate the birds, and soon the latter began to shake their heads and scratch their ears. In this way one of them succeeded in digging the larvae out of one ear, but the other six remained well in. I also tried to make the larvae "take hold" of the skin under the feathers of these birds, but they dropped off as soon as the chick shook itself.

Two days later one of the chicks died but post-mortem showed the cause of death to be a tumor in the left cerebral hemisphere, not connected in any way with the experiment. One larva was found in the right ear of this chick, the only one left of the four put on it, and this one died soon after without reaching maturity.

The fourth day after putting in the larvae, I examined the remaining bird's ears with a soft probe. Both cavities were free of larvae. The chicks had been kept in a case with a false wire bottom, two inches below which was the true bottom covered with half an inch of soil so that if the larvae emerged they would not be eaten by the chick but might pupate. After finding that the larvae were not in the ears, the soil of the cage was gone over carefully but no larvae or pupae were found.

Some of the larvae, especially the larger ones, were left on the floor of the crow's cage and the nest was not cleaned up. Eight days later ten puparia were found under a large piece of paper on the floor of the cage. As the cages were screened from other flies, these must have come from the same larvae. Furthermore, they were identical with the one larva which did pupate in the laboratory. The pupae were in quite a dry place, away from the wet fecal matter of the cage. They were removed to a stender jar and kept moist with a wet filter paper hung in the top of the jar.

In the hope of learning more of the habits and distribution of these larvae, I began visiting birds' nests in the vicinity of Ithaca. I went first to the crow's nest from which the infected birds were taken, just one week after their removal. Crows' nests are from one and a half to two feet in diameter; six inches to a foot deep, and contain a large quantity of rich moist earth below the grass which lines the nest. They are seldom used more than one year. I examined the debris and earth of this nest carefully but found neither larvae nor pupae of the form I was seeking. Subsequently I examined three other crows' nests but found none of the parasites. I have also examined seven swallows' nests (*Hirundo erythrogaster*), all but one of which still had young in it. These also had no larvae. In a house-wren's nest (*Troglodytes aedon*) in a hollow stump, one anthomyid larva was found, but no *Protocalliphora azurea*. Two sparrows' nests (*Passer domesticus*) yielded negative results, as did the examination of one robin's nest (*Merula migratoria*).

An instance of what was very probably an infection of *Protocalliphora* was reported to me shortly after this by Mr. W. D. Funkhouser. While walking in the woods he found a nestling chipping sparrow (*Spizella socialis*) lying in the path. The bird was quite old, almost fully feathered and he could not think what ailed it. As he

held it in his hand a small dipterous larva crawled out from beneath the skin of the neck back of the ear. It was about a quarter of an inch long, and seemed to him of a whitish color. Mr. Funkhouser had no place to keep the larva so he did not save it. He brought the bird home but it died after a few hours and was not examined further.

At the time these observations were made I had no idea that similar ones had been recorded before. They immediately suggested, however, the case of the Congo floor maggot, *Auchmeromyia luteola* (Fabr.), which is also blood-sucking in its habit. The larva of this muscid, which is quite widely distributed in Africa, especially in the Congo region, parasitizes the natives by piercing the skin and sucking the blood. From the account of its habits given by Dutton, Todd, and Christy it appears to be an intermittent feeder, just as *Protocalliphora,* living in the soil on the floor of the huts and feeding at night when the natives are sleeping on the ground. Roubaud (1913) mentions several species of the genus *Choeromyia* which occur in the Soudan and Timbuctoo regions, whose larvae have similar habits, and suck the blood of aard-varks and wart-hogs. But I was not aware that the occurrence of a blood-sucking larva on birds had been reported until the adult flies had emerged. Then on identifying them, I found the following accounts of the larval habits of this species.

The most careful discussion is given by Leon Dufour (1846). In the spring of 1845 he accidentally discovered some larvae on some young swallows in a wooden box-nest in his garden. He found many more of the larvae and some pupae on the floor of the box and on the ground beneath, and reared the adults. He noticed the "short and fine downy velvet" of the integument, which gave it a grayish appearance, and the "footless and headless" character, and soon guessed the larva to be a parasite. He dissected several specimens and found the alimentary canal full of a dark-red fluid which looked like blood, so he inferred that they were blood-sucking in habit. But he did not definitely know this and in fact was not completely assured of it, because he thought parasitism by such a large number of maggots, would almost necessarily affect the health of the young birds; but this was not the case, as the latter matured and flew. The same old pair of swallows had a second brood in mid-August which were less numerously parasitized than the first litter.

Scheffer is reported by Rossi in 1848 to have taken the larvae of this species from a brood of larks. The larks died. Kirsch in 1867 describes what are apparently the larvae of *P. azurea* crawling out of the neck of young sparrows. He did not rear the adults. Nowicki in 1867 also took the larvae from young sparrows.

Brauer in 1867 took *Protocalliphora azurea* "subcutaneously" from nestlings of a swallow (*Hirundo rustica*) and *P. chrysorrhea* (Meig.), a closely related species from *Hirundo riparia*. According to Strobl in 1894 Schieferer took from the grass of a raven's nest ten specimens of *P. chrysorrhea,* both male and female.

In this country Henshaw (1908) notes the occurrence of *Protocalliphora chrysorrhea* on two successive broods of blue birds in Massachusetts. The infestation was so severe that of eight nestlings only one survived.

Du Buysson (1912) attempted to verify Dufour's observations. He found the larvae on swallows June third and obtained pupae, but these had failed to emerge on August 23. He thought that they were resting and would emerge the following spring, but they were probably dead. Rodhain (1914:213) reports finding the larvae and pupae of a muscid in the nests of the grey-headed sparrow (*Passer griseus*) at Bambili in the Congo. He found that these larvae contained avian blood. They were reared but the adult fly had not been determined. It is not, he says, a species of Cheiromyia [misspelling for Choeromyia?].

CONCLUSIONS REGARDING THE HABITS OF THE LARVAE

1. Dufour's suggestion that the larvae sucked the blood of the host is definitely proved by my microscopic examination of the contents of the alimentary canal.

2. The larvae play no part in the transmission of the malarial parasite.

3. They are intermittent feeders. This is based on the following facts: a) Many more larvae were found on the floor than were actually on the birds. b) They seemed perfectly at home there, and moved about in the refuse and on the dry floor quite naturally. c) They were very excitable, and would not settle down or take hold on a bird which struggled and were easily shaken off by the chick. d) One found feeding on a crow which was quiet, immediately released its hold and dropped to the floor when the latter became active.

4. The larvae prefer rather dry places to moist ones and are therefore not accustomed to living in decomposing or fecal material.

5. The larvae do not feed on solid flesh, either fresh or decayed, although they may (Kirsch, Brauer and Funkhouser's observations) bore in living tissues.

From these conclusions it is evident that the species *Protocalliphora azurea* is a blood-sucking parasite on nestling birds, that this habit is normal, not accidental, and that its effect on the host varies, in some instances (Schiffer, Henshaw) being fatal, in other cases (Dufour, my own observations) apparently not affecting the birds' health at all.

The parasitic habit of this species shows a further step in specialization among the larvae of the Calliphorinae. Some members of this group, as flies of the genus *Pycnosoma,* live only on the rich decomposing organic excrement from man and other animals and are therefore quite free-living. The next step may be represented by the species of blow-flies, Lucilia, Calliphora, Homalomyia, etc., which usually live in dead and decaying animal flesh. The tendency towards the parasitic habit is shown, however, in their accidental or facultative parasitism of the higher animals when they find an open sore or decomposing flesh near the living tissue. In such cases they cause myiasis just as do the more usual skin maggots (Chrysomyia, Cordylobia, etc.). The members of the genus Chrysomyia carry this habit further and usually develop in living flesh, wherever there is an abrasion of the skin or bleeding surface, though they can live in decomposing matter. The genus Cordylobia contains the "Thumbu fly" of Africa, *C. anthropophaga,* which normally gains access to and settles down under the skin, showing that it has become exclusively parasitic. Parasites which live on the cutaneous and connective tissues, however, have scarcely attained to as high a degree of perfection in the parasitic habit as those which live on the blood, the most nutrient tissue of their host. The extreme of parasitism in this group occurs, then, in the larvae of those genera which always puncture the skin and suck the blood of their host. Of these there are but three genera known, the two in tropical Africa, Auchmeromyia and Choeromyia, and the genus Protocalliphora which has been found in Europe and North America. The length of life of the larva is probably between fourteen and twenty days.

STRUCTURE OF THE LARVA

Weismann in 1864 believed there were three larval stages or instars in the blow-fly (Calliphora). Hewitt (1908) has shown that there are three in the development of *Musca domestica,* and this is generally thought to be the number in the Muscidae. I presume that there are three larval stages in *Protocalliphora azurea,* although I have found larvae in the last two stages only. The structure of the larva is essentially the same as that described for the Muscidae and is best described by reference to the accompanying drawings (Figs. 1 to 5).

The larvae are 6.0 to 7.0 mm. in length in the second instar and but little larger after the moulting. I find that there are but twelve segments in the larva. The first of these, called by Henneguy the "pseudo-cephalon," corresponds to the head of the more generalized larvae, although in the Muscidae it is very much degenerated. In *Protocalliphora* it is small, membranous, and not covered with spines, as the following segments are. It differs from other larvae of the

muscid type in that it is completely retractile, the entire segment being reflected, as Dufour says, "like turning a glove outside in," when the larva is sucking. When extended it is divided on the ventral side by the pharyngeal cavity from the dorsal edge of which the two mandibular hooks project. On the dorsal aspect the two halves of the segment are united over the hooks, and the lateral portions project cephalodorsad in two pairs of small tubercles.

The mandibular hooks (Fig. 2) are the distal sclerites of a large, chitinized structure which extends back in the body as far as the second or third segment, and which is the chief prehensile organ of the larva. It is made up of several sclerites and is termed by Hewitt in the housefly the "cephalopharyngeal skeleton." The mandibular sclerites are two in number in Protocalliphora, as in Calliphora (Lowne) but in

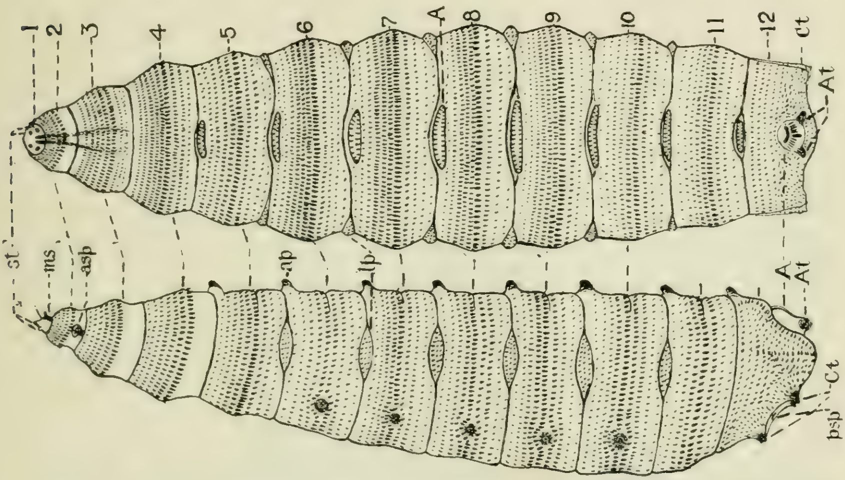

Fig. 1.—Ventral aspect of second and lateral of third instar. X 10. (*A*) anus; (*ap*) abdominal pad; (*asp*) anterior spiracle; (*At*) Anal tubercles; (*Ct*) caudal tubercles; (*lp*) lateral pad; (*ms*) mandibular sclerite; (*psp*) posterior spiracle; (*st*) sensory tubercles.

Musca domestica there is but a single median sclerite according to Hewitt. The remaining segments of the body present the peculiarity of being more or less covered with rows of sharp-pointed, hard, chitinous spines or scales. This spiny coat gives the larva the characteristic dirty brown color and velvety look previously mentioned, instead of the smooth creamy-white appearance which most muscid larvae have. In the second instar the spines are minute and some distance apart but after the next moult they are much larger and more closely packed and form a veritable coat-of-mail.

I believe that the second, third, and fourth segments correspond to the pro-, meso-, and meta-thorax, respectively, agreeing with the inter-

pretation of Weismann, Brauer and Lowne. There is no evidence on any of my specimens of a constriction dividing the second segment into two, as Hewitt found in the house-fly, and the arrangement of spines may be taken as an additional indication that this is but a single segment.

Extending cephalad from under the anterior margin of the third segment on the two lateral sides of the larva are the anterior spiracles

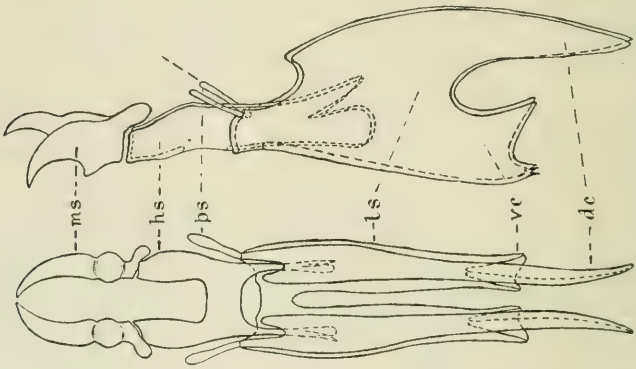

Fig. 2.—Cephalo-pharyngeal skeleton in dorsal and lateral aspects. X 75. (*dc*) dorsal cornu; (*hs*) hypostomal sclerite; (*ls*) lateral sclerite; (*ps*) parastomalsclerite; (*vc*) ventral cornu.

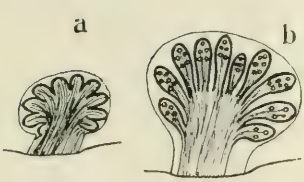

Fig. 3

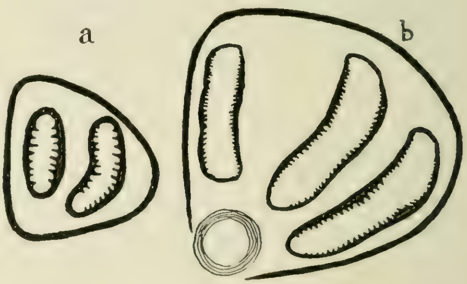

Fig. 4

Fig. 3.—Anterior spiracles of larva; (*a*) second instar; (*b*) third instar. X 125.

Fig. 4.—Posterior spiracles of larva; (*a*) second instar, X 125; (*b*) third instar, X 250.

(Fig. 3). They are small and probably not functional in the second instar, but in the third stage present ten well-developed ostioles or papillae, covered by a delicate membrane. Each ostiole has several small pores in it which apparently are functional.

The fifth to the twelfth segments correspond to the abdomen. Each segment has on its ventral side, near its cephalic border, a transversely

elongate, oval, elevated pad. These "locomotory pads" (Hewitt) are homologous to the abdominal prolegs of lepidopterous larvae. In addition on the sides of the body there is between each of the segments except the last two, a small but constant spindle-shaped lateral piece (Fig. 1).

The twelfth segment is considerably modified by the posterior spiracles and the anus; its form and the arrangement of structures may be readily made out by reference to the figures. The posterior spiracles, two in number, lie in the depressed quadrilateral area of the segment which looks dorso-caudad. There are two large elongate ostioles, surrounded by a chitinous ring, in each spiracle during the second instar but there are three ostioles in the third (Fig. 4).

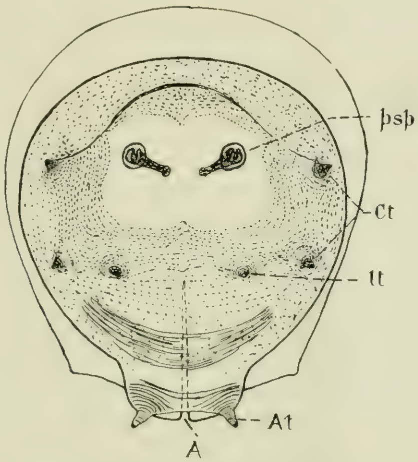

Fig. 5.—Caudal aspect of larva; second instar. X 20. (*lt*) lesser tubercle.

THE PUPA

The larvae when ready to transform, apparently leave the more occupied parts of the nest in the vicinity of their food-supply and seek a dry, quiet portion, usually at the bottom. They seem to transform normally in such places, instead of in the earth as most of the Sarcophagidae do.

The adult emerges from the frontal end of the puparium as in all of the Cyclorrhapha. First a longitudinal slit is made in a frontal plane extending caudad from the larval mouth-opening in a line which passes just ventrad of the anterior spiracles. When this slit has been extended as far as the fifth segment, the dorso-ventral pressure on the two portions is so great that a circular splitting commences. This begins at the lateral faces of the fifth segment and extends dorsad

and ventrad far enough to allow the two anterior portions to spread apart as the fly emerges. They then spring back into place and usually remain attached, each portion connected to the rest of the puparium by a small part of the dorsal and of the ventral walls, respectively. Dufour noticed the longitudinal split on Protocalliphora, but thought that it occurred secondarily to the circular splitting.

Whether this manner of splitting occurs in many of the Cyclorrhapha or not is difficult to say. Most writers remark that the flies emerge by splitting off a circular "cap" at the anterior end. Hewitt however, in a careful study of the house-fly states that "the fly pushes off the anterior end in dorsal and ventral portions . . ." "The splitting of the anterior end of the pupal case is quite regular, a circular split is formed in a line below, i. e., ventral to the remains of the anterior spiracular processes of the larva."

Professor Johannsen states that in all the individuals of the Calypterae whose puparia he has noticed, including Sarcophaga, Lucilia, Calliphora, and Musca, the "cap" is always split in a diametric line as well as circumferentially.

The size of the puparium varies from 6.0 to 9.0 mm. in length, from 2.2 to 3.4 mm. in width (laterad) and from 2.1 to 3.2 mm. in depth (dorso-ventrad). Its general shape is that of a typical muscid. However, the puparium of *azurea* is not shiny, like that of Musca, Muscina, Lucilia, etc., but has a dull, blackish, and soft or velvety appearance. It is light brown, slightly reddish in color when held towards the light, but when looked at by reflected light it has a very dark or black color. This dull dark appearance is caused by the rows of spines of the larval skin, which have already been described. The length of the pupal life in my experiments was about ten days.

THE ADULT

The adults were kept in a good-sized breeding-cage with moist earth and some pieces of meat, both fresh and putrid, and were fed on crackers and milk, which they ate readily. They were not attracted to the flesh at any time, as other blow-flies are, and preferred the crackers and milk for food. It is evident, therefore, that the adults as well as the larvae are quite different in their habit from the commoner Calliphorinae.

Both *Protocalliphora azurea* and *P. chrysorrhea,* which is closely related to it in structure and habits, are recorded by collectors and dipterologists as "rare" or "very rare," and specimens are found only in the larger museums and collections. I am inclined to think, however, that they are not so rare as is generally supposed, but that the adults are peculiar in their habits, flight, etc., and for this reason are rarely

taken. From the habits of the larvae we would scarcely expect to find the adults around dung-heaps, decaying flesh, and similar places where the Calliphorinae are usually sought for. Few collectors, I imagine, have taken insects very often from the zone of air from fifty to one hundred feet above the ground, in the woods; yet from the habits of the larvae, this is where we would naturally expect that the adults would occur. And the contents of birds' nests have not been studied to any appreciable extent from an entomological point of view. It seems probable, therefore, that they may be fairly common in spite of the few times they have been taken.

Protocalliphora azurea has been reported from two or three places in France and a few places in Germany and Italy, and Walker reports one specimen in the British museum collection. In North America Hough declares the species "very rare." Mr. C. W. Johnson has kindly noted for me, however, that there are three specimens in the collection of the Boston Society of Natural History, all taken in New England within the past few years.

In its parasitism the species is not limited to a single host but it seems to occur more frequently among the birds which build more protected and stable nests, as in boxes of earth, etc.

The species was first described by Fallen in 1816 under the name *Musca azurea*. Meigen listed it under the same name in Systematische Beschreibung. In 1845 Dufour, on the authority of Macquart, gave the species which he had reared the name *Lucilia dispar*. Schiner in Fauna Austriaca described Fallen's species as *Calliphora azurea* and remarked that after comparing Dufour's specimens he determined that *Lucilia dispar* is a synonym of *Calliphora azurea*. Rondani classified the species *azurea* as belonging to the genus Pollenia. Finally, Hough in dividing up the North American genera of Calliphorinae created a new genus, Protocalliphora, and takes as the type species the one under present consideration, the *Musca azurea* of Fallen. Two years later Hendel, unaware of Hough's work, recognized the same differences and erected the genus Avihospita. The latter therefore falls as a direct synonym of Protocalliphora.

Since the species has not been taken often, and since no very detailed description of the adult is available, I offer the following additions to the specific characters which other authors have given: size, 7.6 to 10.0 mm.; head, in the female, twice as broad as long, and as broad as the thorax and abdomen (from 2.5 to 3.0 mm.). The second segment of antennae is reddish-yellow with large black hairs; third segment, including the arista, black. (Hough states that the antennae are black, without noting that the second segment is always brown or yellow). The median half of front, from vertex to antennary

fossa, is clothed with soft short black hairs, giving it a downy appearance; each lateral quarter of front is scaled with comparatively large white scales. The cheeks (bucca) are metallic blue, with a rather sparse, coarse black beard; palpi are moderate-long, reaching to the oral margin, and reddish-yellow in color throughout (sometimes quite a dark brown); they are clothed with black hairs which are quite long towards the apex.

The chaetotaxy of the head is as follows; ocellar pair of macrochaetae, mid-way in each ventral side of the ocellar triangle present, besides several microchaetae within the triangle; two pairs of verticals present, the inner pair larger, convergent, and decussating near the tips, the outer pair divergent; in front of, and between the verticals, is a pre-vertical bristle. There are two pairs of fronto-orbitals. The

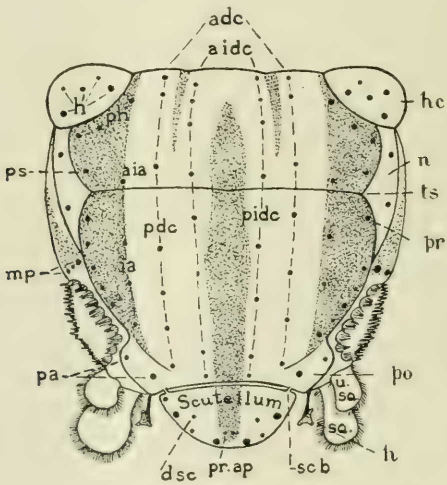

Fig. 6.—Dorsum of thorax in adult. X 10. (*adc*) anterior dorso-centrals; (*aidc*) anterior inner dorso centrals; (*aia*) anterior intra alar; (*dsc*) dorsal scutellar; (*h*) humerals; (*ia*) intra alars; (*pdc*) posterior dorso centrals; (*pidc*) posterior inner dorso centrals; (*ph*) post humerals; (*pa*) postalars; (*pr ap*) pre-apical; (*ps*) pre-sutral; (*sa*) supra alars; (*sc b*) scutellar bridge; (*sq*) lower squama-squamula thoracalis; (*u sq*) upper squama-squamula alaris.

row of frontal bristles is fairly constant and well-developed, usually nine, sometimes eight or ten. I have no specimens of the male.

The thorax is a lustrous metallic steel blue color, throughout. On the dorsum, however, this blue color is overlaid by a fine whitish bloom, which covers most of the mesonotum, except in definite areas where the blue shows through. These areas are indicated on the drawing of the thorax (Fig. 6). The squamae are prominent, whitish-colored, and covered with a very fine down on both surfaces, with a fringe of longer hairs around the edge. The legs are black; the halteres white. The

wings when at rest are folded over the abdomen, their outer (anterior) margins parallel to the body. The wing venation is very constant in the smallest details, and is as described in other works.

The position and numbers of the various macrochaetae which are constant on the thorax in this species may be seen from the accompanying drawings (Figs. 6, 7). They are as follows: on the dorsum, the anterior inner dorso-centrals (acrostichals), composed of four well-developed macrochaetae (*a idc,* in figures); the posterior inner dorso-centrals (*p idc*), also containing four bristles, each present in all the specimens I have examined, although they vary somewhat in size, and frequently in position (the second and third posteriors most often). This differs from Hough's observation that the posterior acrostichals vary in number or are poorly developed in *Protocalliphora.* The anterior dorso-central bristles (*a dc*) are three in number, the posterior

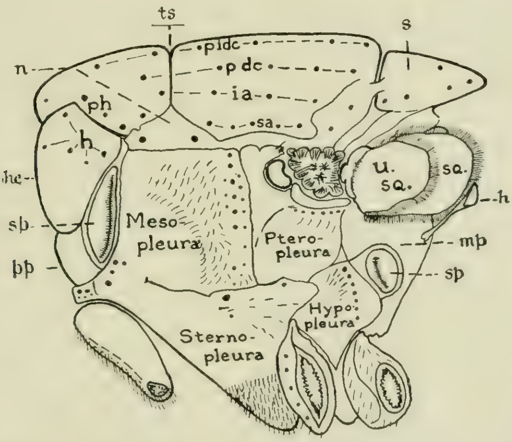

Fig. 7.—Lateral aspect of thorax in adult. X 10. (*h*) halteres; (*hc*) humeral callus; (*mp*) metapleura; (*n*) notopleur; (*po*) postalar callus; (*pp*) propleura; (*pr*) prealar callus; (*s*) scutellum; (*sp*) spiracle; (*ts*) transverse suture.

(*p dc*) four; the intra alars are three in number (*i a*). A single small anterior intra alar (*a ia*) is present, three to five supra alars (*sa*), and one presutural (*p s*). There are three posthumerals (*p h*), five humerals (*h*), and two well-developed post alars (*p a*). The scutellum has a peripheral row of bristles which varies in number from six to ten (three to five on each side); there is sometimes an odd number of them, due to the presence of a macrochaeta on one side without a mate on the opposite side. These bristles have each been given an individual name by Girschner, but since their development seems more or less irregular and inconstant, I simply call them the peripheral row. In addition to these I have found two pairs of bristles on the dorsal

surface of the scutellum. The dorsal scutellar pair (*d sc*) (so-called by Girschner), are not in line with the inner dorso-central row but laterad of it. The pre-apical scutellars (*pr ap*) are quite small, but are markedly different at the insertion from the microchaetae. Both pairs are present in all of my specimens.

Not having any male specimens of *Protocalliphora azurea*, nor any specimens of *P. chrysorrhea*, to examine, I can not tell whether this arrangement of bristles on the scutellum is a specific character or not. But I strongly suspect from the work of Girschner and from a comparative study of these bristles in Luciliar, Phormia and Calliphora, that it is a generic rather than a specific or sex character.

There are two macrochaetae on the notopleura; the mesopleurals are usually seven in a vertical row, the second from above sometimes rather undersized. In two cases there are eight, the extra one being in

TABLE OF MICROCHAETAE ON THE NOTOPLEURA OF PROTOCALLIPHORA AZUREA

Specimen No.	Bristles Before the Posterior Macrochaeta	Bristles Behind the Posterior Macrochaeta
1 L (left side)	8	6
R (right side)	8	7
2 L	8	5
R	8	4
3 L	7	3
R	16	4
4 L	10	5
R	8	4
5 L	8	5
R (destroyed)	..	..
6 L	7	3
R	5	3

the space before the last bristle. The pteropleura is quite bare save in the region under the wing-base, where there is a row of from four to six rather small macrochaetae. The hypopleural row is composed of seven well-developed and constant macrochaetae. On the dorsal margin of the sternopleura there are three bristles. The long microchaetae on the sides of the sternopleura gradually become more dense ventrad, and the individual hairs also become much thicker, until they must be called macrochaetae. They are too numerous to be readily counted. There are a number of macrochaetae on each coxa. Near the cephalic margin of the fused mesopleura and sternopleura are four macrochaetae, arranged as indicated in the figure. Two of them are much smaller than the other two. More cephalad still, between the propleura and the front coxa are two other bristles.

Since the work of Osten-Sacken the importance of chaetotaxy in the classification of certain groups of the Diptera has been well recognized, and it has been suggested that since setae occur in every form and size between the macrochaetae and the microchaetae, there must also be a very definite microchaetotaxy in the various genera and species. As a preliminary record on this point, I have counted the microchaetae on the notopleurae of each of my specimens.

Those anterior to the posterior macrochaetae are fairly constant in number, though there seems to be no very regular arrangement. There are usually eight, but sometimes six to ten. Those behind the posterior bristle gradually taper off to such minute hairs as are scarcely visible, and vary irregularly in number (from three to seven).

For comparison with other genera I have counted specimens of *Lucilia sericata* and *L. caesar,* of *Calliphora erythrocephala, C. viridescens,* and *C. vomitoria,* of *Protophormia terrae-novae,* and of *Phormia regina.* The exact number of microchaetae is not the same in all specimens of the different genera, nor on the same sides of the same specimen. Nevertheless there is in each genus a general range within which all members fall, and this is so constant that I am convinced that it is at least of generic significance. Thus, in Phormia the number ranges from thirteen to nineteen, the majority having sixteen; in Lucilia there are from fourteen to twenty-five, the majority having twenty plus; in Protophormia the range is from fifteen to thirty, the majority grouping around twenty-six; while in Calliphora there are a great many more, the number running from thirty to seventy-five, with the majority having a number in the vicinity of forty.

The abdomen has the typical muscid shape. It extends 3.5 to 4.0 mm. beyond the end of the scutellum, only four segments showing in the dorsal aspect. The color of the abdomen in the females is a metallic blue-green on the first three segments, the tip being a lighter golden green. It is slightly pollinose (less so than the thorax) so that in some aspects it has a whitish appearance. It is covered by rather long black microchaetae, which on the caudal margin of the last two segments become enlarged and thickened and are practically macrochaetae.

SUMMARY

Protocalliphora azurea, a Muscid larva, occurs as a normal blood-sucking parasite of nesting birds, with fatal results in some cases. This represents the extreme specialization of these larvae towards parasitism; many intermediate stages are also represented in other members of the group.

The structure of the larva and of the pupa are described in detail, and also the habits and distribution of the adult. The anatomy of the adult is discussed with especial emphasis on the distribution of the bristles as this is very regular and of marked significance in taxonomy.

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EXPERIMENTS ON CYSTICERCI OF TÆNIA PISIFORMIS BLOCH AND OF TÆNIA SERIALIS GERVAIS *

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The life histories of the dog tapeworms, *Tænia pisiformis* Bloch and *Tænia serialis* Gervais, are understood, but to what extent other vertebrates than the usual hosts constitute suitable environments for the development of the ingested cysts of these tapeworms is a question that deserves further consideration. This question, together with the custom of feeding to chickens the common wild rabbit (*Lepus floridans mearnsi* Allen) and the hare or jack-rabbit (*Lepus campestrus* Bachm.), led the writer to carry on some experiments to ascertain whether *T. pisiformis* and *T. serialis* will develop in fowls.

As is known, the common wild rabbit or cottontail is the intermediate host of *T. pisiformis*. The larval form (*Cysticercus pisiformis* Zeder) develops in the peritoneal cavity, omentum, and mesentery. In eastern Kansas a high percentage of the cottontails is infected with these cysticerci; Scott (1913) examined sixty-four cottontails taken in this vicinity and found this cyst in nearly 84 per cent. of them. All of the rabbits used in these experiments contain *Cysticercus pisiformis.*

The chickens used in the experiments were kept from the time of hatching in a fly-proof enclosure and fed upon food free from animal tissues. In the first experiment, the cysticerci were removed from the omenta and mesenteries of the rabbits and fed at once to the fowls, care being taken to prevent injury to the cysts before they were swallowed. *Cysticercus pisiformis* was fed to three chickens. To the first, five on July 8 and sixteen on July 10. To the second, five on July 8 and ten on July 10. To the third, twenty-three on July 13. Two months later (September 5, 8 and 12, respectively) an examination of these chickens failed to reveal a tapeworm.

It is known that the intermediate host of *T. serialis* is the hare or jack-rabbit, although the cottontail occasionally harbors the multiple cyst, *Coenurus serialis Gervais,* of this cestode. The seat of infection is in the connective tissue, particularly intermuscular, of the head, neck, thorax, loins and limbs.

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* Contribution No. 6 from the Zoological Laboratory, Kansas State Agricultural College. Experiments by aid of Adams fund.

In the second experiment, the multiple cysts (with one exception) were not removed from the loins of the hares until the latter had been dead twenty-four hours. During this time, however, the lowest temperature of the surrounding air was approximately 40° F. In all probability, the cysts were not subjected to a temperature sufficiently low to impair their vitality, for Ransom (1914) has demonstrated that a prolonged (six days) temperature of 15° F. is required to kill *Cysticercus bovis* in beef. Nor is it at all likely that the length of time was sufficient to seriously lessen the vitality of the cysticerci, as Baillet (1863) has found that *Cysticercus pisiformis* maintains its vitality for as many as eight days after it has been exposed to the air. Multiple cysts were removed from the hares and fed to three chickens. To the first, one on July 8 (immediately after the death of the hare). To the second, twenty-four on December 12. To the third, twenty-two on December 12. On September 5, January 16 and 30, respectively, these chickens were examined and in no case was a tapeworm found.

In looking up the literature on these two cestodes, the writer was surprised to find so many records of attempts to infect mammals with the cysticerci of these tapeworms. Moniez (1896) fed cysticerci of *T. serrata* to two human volunteers and no tapeworm developed. In 1898, Galli-Valerio swallowed six of these cysts without developing a tapeworm. Hall (1914) ingested three *Cysticercus pisiformis* from a freshly killed rabbit with no results. In 1913, Scott fed *Cysticercus pisiformis* to swine and in no case did a tapeworm develop. The failure of attempts to infect swine, fowls and man with *T. pisiformis* indicates that this tapeworm is somewhat specialized with reference to its host.

So far as the writer has been able to ascertain, *T. serialis* has not been reported from man. Galli-Valerio (1909) ingested two living scolices from *Coenurus serialis* without experiencing any discomfort and without becoming infected. Hall (1910) failed to develop a tapeworm after swallowing three living scolices from this cyst. Hence, it appears that *T. serialis* cannot develop in man. The attempt of Thomas to infect cats and ferrets by feeding to them the larvæ of *T. serialis* failed, according to Hall (1910). And Scott (1913) on feeding these cysticerci to pigs was likewise unable to infect them.

SUMMARY

From the experiments reported in this paper it appears that *T. pisiformis* and *T. serialis* will not develop in fowls. Previous investigations show that *T. pisiformis* fails to develop in man and in swine, and that *T. serialis* does not develop in man, swine, cat and ferret.

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SOCIETY PROCEEDINGS

THE HELMINTHOLOGICAL SOCIETY OF WASHINGTON

The twenty-second regular meeting of the society was held at the residence of Mr. Hall on October 29, Mr. Hall acting as host. The evening was devoted to an informal discussion of zoological and medical topics.

MAURICE C. HALL, *Secretary.*

The twenty-third regular meeting of the society was held at the residence of Dr. Pfender on December 17, 1914, Dr. Pfender acting as host and Dr. Stiles as chairman.

Dr. Sweet was elected a foreign corresponding member of the society.

Dr. Ransom presented a paper by Ransom and Hall, entitled The Life History of *Gongylonema scutatum.* Encysted larval nematodes were found by the senior author in the body cavity of *Aphodius femoralis, A. granarius, A. fimetarius,* and *Onthophagus hecate* at Bethesda, Maryland. Certain morphological characters suggested the possibility that they were the larvae of Gongylonema. Furthermore, dissections of larval beetles of these and related species disclosed the presence of free nematode embryos which agreed exactly with embryos taken from the eggs of *Gongylonema scutatum.* Nematode larvae similar to those discovered at Bethesda were found in *Aphodius coloradensis, A. vittatus,* and *A. granarius* in El Paso County, Colorado. The feeding of these larvae to sheep resulted in infestations with *G. scutatum.* Eggs of *G. scutatum* were fed to *Aphodius* spp. and to Croton bugs, *Ectobia germanica.* In the course of two days free embryos of *G. scutatum* were recovered from the insects; later, other stages were found, and at the end of a month the final encysted larval stage was present. Small dung beetles belonging to the genus Aphodius, appear to be the most common hosts.

Dr. Cobb presented a very unusual note, dealing with a new species of free-living nematode, which has been made the subject of some experiments and observations arising from the presence in its intestinal cells of the substance rhabditin, described in a former paper presented before the society. It has been found possible to rear several successive generations of this nematode on agar made up with only those traces of nitrogen contained in tap water and "pure" agar. Simultaneously it has been determined that the nematode is aerophagous, and Dr. Cobb exhibited to the society a preparation in which the living nematode was shown actively ingesting air. The nematode can take in its own volume of air in the course of an hour or two, the air passing into the esophagus being visible as bubbles taken in at the surface of the nutrient medium, to which the nematodes resort from time to time. This ingested air may be followed as it passes quickly through the esophagus and as far as the anterior portion of the intestine where it is rapidly and completely absorbed, each bubble of air as it reaches the intestine requiring only two to three seconds for its absorption. The obvious conclusion suggested by the development of several generations of this nematode on a "nitrogen-free" medium and its habit of swallowing air, is that the nematode, among other things, has the power of fixing atmospheric nitrogen. The cultures were not free from bacterial contamination, though the contamination was not heavy; it was possible by frequent transfers of the nematode to keep them in relatively pure media. The most significant feature of the observations is the undoubted ingestion and absorption of relatively large quantities of nitrogen. The development of the nematode under the conditions named does not appear to reduce very materially the amount of rhabditin.

Dr. Cobb also exhibited to the society some mounts of free-living nematodes, showing elaborate structures and a remarkable trigger-like process anterior to the cloacal aperture in the male.

Mr. Foster presented a paper entitled The Use of Vermifuges in the Treatment of Swine. He finds oleum chenopodii very satisfactory, comparing very favorably with santonin. Coal tar creosote was not found to be satisfactory.

Mr. Hall presented a paper entitled A Note on *Syngamus laryngeus* from Cattle and Carabao in the Philippine Islands. This paper records the parasite for the first time since its description by Railliet from Annam.

Mr. Hall also presented a note on the ingestion of ascarids by man. An employee of one of the big packing houses in Chicago, a so-called "Polack," working at the gutting bench in the hog room, was in the habit, according to Dr. Woodruff of the U. S. Bureau of Animal Industry, of slitting open the intestines of hogs, where they could be seen distended with *Ascaris suum*, taking a handful of these worms and eating them down in several bites. Dr. Woodruff states that the man showed no visible evidence of ill effects from this habit, which is rather remarkable, as, aside from the esthetic repugnance which would be sufficient to make the average person sick, ascarids have certain toxins which often affect helminthologists unpleasantly on merely working with these worms, some persons developing a hypersusceptibility which makes the presence of the worms in the same room intolerable. The case must be regarded as an individual idiosyncrasy, suggestive of mental defects, physiological disturbances, or some such pathological condition. In this connection it may be noted that all reports that the inhabitants of any section of Italy are in the habit of eating ligules have met with strong and indignant denials on the part of the Italian helminthologists.

Dr. Stiles gave a talk on sanitary conditions in the southern United States, emphasizing the good effects to be anticipated in dealing with problems of this sort in a quiet, personal way and avoiding unpleasant, undesired, and unmerited newspaper notoriety.

Dr. Pfender gave a very instructive demonstration of the use of radiography, illustrating his points by stereoscopic radiographs and the use of the fluoroscope.

MAURICE C. HALL, *Secretary.*

The twenty-fourth regular meeting of the society was held at the residence of Mr. Chambers on Jan. 28, 1915, Mr. Chambers acting as host and Dr. Cobb as chairman.

Dr. Stiles gave an extended discussion of sanitary conditions in the South, with especial reference to the respective merits of the pit privy and the so-called "umbrella privy".

Mr. Chambers exhibited a figure of a new free-living nematode from Panama, the worm being provided with three jaws, each of which is armed with three rows of retrorse teeth.

Dr. Cobb exhibited a Baker collapsible microscope.

The secretary presented a note by Mr. Crawley in regard to the protozoa found in the cloaca of frogs, with special reference to variations in Opalina.

MAURICE C. HALL, *Secretary.*

BOOK REVIEWS

A REVISION OF THE CESTODE FAMILY PROTEOCEPHALIDAE. By George R. LaRue. Illinois Biological Monographs, Vol. I, Nos. 1 and 2. Urbana, Illinois. 1914. 350 pp., 16 plates.

This work is the most complete and comprehensive yet published on the proteocephalid tapeworms. The author has gathered together and carefully compiled the observations of other investigators on this group, and with this compilation he has combined in monographic form a large mass of data collected from his own studies on the various species of the family. The Proteocephalidae occur in fresh-water fishes, reptiles and amphibia, and comprise five genera and about fifty species. Excepting the genera *Acanthotaenia* and *Corallobothrium* which are only touched upon incidentally, the author has covered the various species not only of this group but also those belonging in the genus *Monticellia* LaRue, 1911 (*Tetracotylus* Monticelli, renamed), which he separates from the Proteocephalidae as the type of a nearly related but distinct family, Monticellidae. The morphology, which is illustrated with 199 figures, synonymy, host records, etc., are fully discussed for each species. The portion of the work pertaining to general questions such as geographical distribution, host relationships, etc., is of special interest to economic zoologists, because as already pointed out by Ward (1910) valuable clues in clearing up certain problems in the biology of food fishes are likely to be picked up from a knowledge of fish parasites.

THE PROPHYLAXIS OF MALARIA WITH SPECIAL REFERENCE TO THE MILITARY SERVICE. C. F. Craig. War Department: Office of the Surgeon-General. Bulletin No. 6. Government Printing Office, Washington, 1914. 115 pp. 12 plates.

This pamphlet, published for the information of medical officers in the army, gives a careful and clearly written synopsis of present knowledge on the organism of malaria and its transmitting agents. The work opens with a discussion of the methods for studying both living and preserved material, the structure, life history and habits of the various species of Plasmodium occurring in man and of the types of Anopheline mosquitoes that transmit them. Further chapters deal in extenso with the prophylactic methods and their application to the military service. At the close is given a bibliography of important references which though complete contains some errors and irregularities of citation that may embarrass inexperienced students.

THE ANALES DE ZOOLOGIA APLICADA, recently established in Chile is devoted to the biological and systematic study of animal parasites (Arthropoda, Vermes, and Protozoa) of the neotropical region. The editor, Professor Carlos E. Porter, Director of the Zoological Museum at Santiago, is known for extensive and valuable work in research and as editor of the Revista Chilena de Historia Natural.

THE PARASITIC AMOEBAE OF MAN. By Charles F. Craig, M.D., Captain Medical Corps, U. S. A., Pp. x + 253, thirty figures. Philadelphia: J. B. Lippincott Co., 1914.

In his preface the author emphasizes the desirability of a work of this nature, owing to the great importance of amebic infections of the intestine and liver in man, and to the great frequency with which such infections are met both in our tropical possessions and in certain parts of this country.

The first chapter gives a historical review of the important investigations relating to amebae found in man. In the second chapter the morphology and

biology of amebae, and the methods of reproduction are discussed with a brief historical review of the resistance of amebae to physical and chemical agencies. In a discussion of the classification and nomenclature of the organisms Craig points out that a pathogenic and non-pathogenic species of ameba in man were first demonstrated by American investigators rather by Jürgens and Schaudinn. It is true that from a zoological standpoint Schaudinn gave the most complete description of two species of amebae found in the intestine in man, but a number of his observations regarding one species are unconfirmed. As Craig points out, however, Schaudinn's classification has been generally accepted by zoologists, although few have observed the morphological characteristics of *Entamoeba histolytica* he described.

Craig gives complete account of the technic of examination of amebae in the fresh state and the methods to be employed in fixing and staining them. The method devised by Wolbach for the hardening of tissues and staining of trypanosomes in sections, which is also an excellent one for staining amebae in sections, might have been added. The cultivation of these organisms is then discussed and the fact pointed out that all amebae which have been cultivated upon artificial media are free living species and of no etiological significance in dysentery, whereas the parasitic amebae have not been cultivated. In the sixth chapter the distribution, morphology, reproduction, life cycle, attempts at cultivation, and relation to disease of the different species of human intestinal amebae are considered very exhaustively, and the characteristics of the different species illustrated by plates and figures. The differential diagnosis of *Entamoeba coli, Entamoeba histolytica,* and *Entamoeba tetragena,* is also discussed and a table given showing the differential features. The author emphasizes rightly that a differential diagnosis of these species does not rest upon the presence of a single morphological feature, but should only be made after a careful consideration of all morphological data, as well as the life cycle of the organisms investigated. Craig apparently regards *Entamoeba histolytica* and *Entamoeba tetragena* as different species, whereas Walker believes tetragena is a variety of histolytica.

In discussing the amebae of the mouth, Craig points out that the distribution of the common species, *Entamoeba buccalis,* is world-wide, and that while it is sometimes found in carious teeth, there is no experimental evidence connecting it with disease. He shows that it may be frequently demonstrated in material scraped from the roots of perfectly normal teeth, and that so far as the evidence goes, it must be regarded as only a secondary invader of the tissues. It is very doubtful if this form has anything to do with caries of the teeth. The other amebae found in the mouth he agrees with Prowazek are identical with *Entamoeba buccalis.* Brief reference is made to the occurrence of amebae in the genito-urinary tract, in exudations and abscesses, and in the lungs.

The book is well printed, is written in an interesting manner, and constitutes an important addition to the literature on this subject.

The Government Bureau of Microbiology (New South Wales) has a division devoted to animal parasites. Its Third Report includes several important notes by J. Burton Cleland. Coccidia (probably *Eimeria stiedae*), reported for the first time in Australian cattle were found in moderate numbers in the caecum of a cow. More than half the house sparrows examined during 1911 and 1912 were found to be infected with *Isospora lacazei* (Labbe), known in England from various passerine birds. An attempt to introduce this parasite experimentally into chickens was unsuccessful.

The most extended communication is a study of the life history of *Onchocerca gibsoni.* These worm-nests in cattle which had never left Milson's Island gave localized conditions for study. The distribution of the parasite

and the finding of living embryos in subcutaneous situations suggests an insect vector. Either the stable fly (*Stomoxys calcitrans*), or a mosquito (*Culicelsa vigalax*) may be the carrier. Experiments showed that *Stomoxys calcitrans* can ingest living embryos from opened worm-nests and these embryos remain alive and active in its alimentary canal as long as three days. An attempt to infect a calf through *Stomoxys calcitrans* which had ingested living embryos was not successful. Calves could not be infected by embryos taken with milk or injected subcutaneously. The position of worm-nests and free embryos makes it probable that infection first occurs in the lower extremities and that the embryos migrate along the lymph channels.

NOTES

Doctor Richard P. Strong, Professor of Tropical Diseases in the Harvard Medical School, and a member of the Editorial Board of the Journal, has just left for Servia as chairman of the Sanitary Commission sent by the American Red Cross to aid in the control and suppression of typhus, cholera and other epidemic diseases. Doctor Strong's admirable record during the terrible epidemic of pneumonic plague in Manchuria in 1911 makes him an ideal leader for this, which Surgeon General Gorgas believes the most important sanitary work in years.

Professor Doctor A. Looss, the well-known helminthologist, who was formerly pathologist in the Medical School at Cairo, Egypt, retired from that position with the outbreak of the war. He is now in Germany engaged in scientific work, and wishes to announce his address for the future as Stephanstrasse 18, Leipzig.

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THE PARASITE OF ORAL ENDAMEBIASIS, *ENDAMEBA GINGIVALIS* (GROS) *

Allen J. Smith and M. T. Barrett

The pathogenic importance of the endamebae of the human mouth, which formerly were held as innocuous and were but scantily considered by pathologists, has been urged by the writers and others in a series of articles published within the past five or six months.[1] According to this view the writers regard these parasites as either directly causative of a large class of gingival and alveolar pyorrheas or as important members of a symbiotic chain with one or other of the numerous associated vegetable micro-organisms, in the production of these lesions. They find these endamebae also in the tonsils, in cases of chronic cryptal inflammation, often with tonsillar enlargement; and are disposed to regard them as concerned in the production or maintenance of such inflammatory changes of these organs; and moreover, believe that a long series of systemic complications of Riggs' disease and tonsillitis are due in some part to these parasites. Proof of the pathogenic importance of the endamebae in Riggs' disease rests upon their almost constant presence in the suppurating pockets of pyorrhea, and the prompt removal of both suppuration and of the endamebae when emetin, a proved amebicide but of low bactericidal value, is administered locally or generally. The authors hold that an overwhelmingly large group of cases of pyorrhea in which these endamebae are met should be segregated under the name "endamebic pyorrhea," in the same way that dysenteries in which dysenteric endamebae are met are known as "endamebic dysentery"; but reserve a small series of pyor-

* From the Laboratories of Pathology of the Medical School of the University of Pennsylvania, Philadelphia, Pa.

* Presented at Christmas Meeting of American Society of Bacteriologists, 1914.

1. Preliminary report by Barrett: Dental Cosmos, August, 1914. See also Smith: Dental Cosmos, September, 1914. Bass and Johns: New Orleans Med. and Surg. Jour., November, 1914. Smith, Middleton and Barrett: Jour. Amer. Med. Assn., November 14, 1914. Barrett: Dental Cosmos, December, 1914. Cf. Chiavaro: Abst., Dental Cosmos, September, 1914.

rhea cases which cannot be included in this class. In attributing influence of these protozoa in the production of systemic complications the writers follow the general lines of argument as to the influence of "oral sepsis" of Hunter and others, merely emphasizing the endamebae as essentially involved because in their experience in a number of cases such complicating conditions have yielded, along with the oral lesions, to the use of emetin. Among such complications they include various chronic and recurrent arthritides (of the type of arthritis deformans), certain obscure anemias (as some of the splenic anemias and picked cases of pernicious anemia), functional and catarrhal disturbances of the gastro-intestinal canal, and probably, too, cases of degeneration of parenchymatous organs (as kidney and liver), an undefined group of serous inflammations (as of the heart), and perhaps, also, certain chronic functional nervous disturbances (neuralgias, etc.).

If no more of this comprehensive list of disturbances prove ultimately to be caused by these parasites than the local peridental suppurations and, perhaps, chronic cryptal tonsillitis, a careful systematic consideration of the parasites in question would be amply justified; and it is from this standpoint that the present discussion is presented, in an attempt to coordinate the amebiform organisms described by various observers as parasites of the human mouth and to compare them with other and better known forms of endamebae.[2]

In 1849 Gros[3] in a comprehensive article entitled "Fragments d'Helminthologie et de Physiologie microscopique," announced his discovery of an amebic parasite in the human mouth and published therewith drawings of the organism. There is little of importance, other than the announcement of the observation, in his text; but as the drawings are of importance, both are here reproduced (Fig. 1).

AMOEBEA GENGIVALIS

Au milieu des productions du tartre des dents, on voit des vibrios, une sorte de végétation qui est quelquefois très régulière; mais on n'avait pas encore mentionné les vésicules que nous avons représentées, Pl. VI, C. Ces vésicules ont un mouvement si lent et si obscur qu'il faut en étre averti pour remarque qu'elles prennent toutes les formes, par une extension et contraction amoebéenne, laissent toujours voir à l'intérieur des globules qui semblent se déplacer un peu, et étre l'analogue de ce que nous connaissons chez de certains infusoires soi-disant polygastriques. Leur origine, leur rôle et leur fini sont ignorés. Elles se trouvent surtout à la face interne des dents. Est-ce encore une génération spontanée?

2. This spelling is adopted by the writers instead of *entameba*, proposed by Casigrandi and Barbagallo in 1897 (*Ann. d'Igenie,* vol. 7, p. 103), because in 1879, Joseph Leidy (*Proc. Acad. Nat. Sci.,* Philadelphia, vol. 31, p. 204), then professor of anatomy in this school, proposed the generic name *endameba* for a parasitic ameba of the cockroach (*endameba blattae*). Aside from a feeling of personal loyalty to Dr. Leidy the writers are impelled by the rules of priority to adopt his nomenclature.

3. Gros: Bull. Soc. imp. de nat. de Moscow, Vol. 22, No. 2, pp. 549-573.

No one can look upon the drawings of Gros and fail to be convinced that he actually found amebae; and, if the size of the globules contained within them be accepted as that of the globular remnants of undigested leukocytic nuclei such as are commonly found in mouth endamebae, that the organisms were of about 0.025 to 0.030 mm. in diameter; that they threw out broad, rounded lobose pseudopodia and that in these pseudopods and at their bases a clear hyaline ectosarc was distinguished from a granular endosarc containing the coarse globular material. It may be accepted that these points, together with the habitat of the organisms upon the dental surface and in soft tartars were established by Gros.

In 1862, Steinberg,[4] in his thesis before the University of Kiev, in which he gives the details of his observations upon the living forms he encountered in the *substantia mollis alba* (soft tartar and refuse) about the teeth, probably refers, among other animal and vegetable organisms, to the same ameba announced by Gros thirteen years previously; but it is doubtful whether he had knowledge of the publication by Gros. At least he makes no mention of it, and writes as if under the belief that he is discussing a personally discovered amebic parasite, to which he attaches the name *amiba buccalis.*

The text is very curious but disappointing and there are no accompanying illustrations. However, because the volume containing his observations is rare in medical libraries and because of the difficulty of dealing with the original Russian language, the writers present the following translation, rendered for them by Dr. Fischelis of this city, of that part of the comprehensive article by Steinberg which concerns the matter in question:

AMIBA BUCCALIS

These organisms I met in various forms and sizes. Their characteristics are of a negative rather than of a positive character, in that they have no fixed size (this changing several times a minute); that they have no definite motile organelles (these being substituted by expansions or pseudopodia, appearing now here, now there, on different parts of the body); that they do not present a distinct direction of movement, as the pseudopodia by which they move appear at varying positions on the body and then retract again. The number of pseudopods is not fixed, now none, sometimes one, two, three, four and more; a change in the number of extensions occurring in the individual in a comparatively short time (one or two minutes). The shape of the pseudopodia in a given individual is not fixed, and their length is also variable. Granules are distributed within the body of the ameba and these do not retain any constant mutual relation, or to the individual itself or to the periphery of the ameba. I observed, however, a difference in the amebae seen on different days. While the size of the amebae in a given instance is constantly undergoing change, such change has its limitations; but it can be said that to-day, for example, the amebae observed are generally larger or smaller than those seen upon a previous day. Although the pseudopodia of a given ameba are in constant change, they

4. Steinberg: Souremenaya meditsina, Kiev, 1862, Nos. 21-24.

may in one instance be more obtuse, short and rounded off, and in another larger, less obtuse and not rounded, etc. The body of the ameba with all its variability, depending upon the instability of the pseudopods, preserves a more or less common character or peculiarity, hard to describe; but the experienced eye of the observer notices and recognizes this peculiarity. In a given ameba, for example, there are always pseudopods present; in another there are times when none are to be seen. In a word, the total summation of a series of characteristics which are individually of no importance enables the observer to conclude, for instance, that he has before him not one single type of amebae but various amebae.

Having observed amebae in the soft white substance about the teeth and those in various infusions, I was able to convince myself that with all their indefiniteness of outlines and size there are certain features characterizing all amebae, viz., all change their positions by means of their pseudopods. Following the movements of various amebae I have always noted that first on some side of the body of the organism there appears a visible thickening, at first showing as a light and almost transparent cloud; this thickening (a pseudopod) grows more and more, eventually taking on a color nearly like that of the body of the ameba and then after one-half, five, ten, twenty minutes, when it has attained a certain size and form, it remains for a time fixed, as if it were adhering to the glass and becoming hardened in that position. Then the whole body of the ameba moves toward the point where the pseudopod has become fastened and coincidently the pseudopod diminishes, even to disappearance (at least it becomes invisible to the eye of the observer). During the time of the formation of the pseudopod, particularly toward the end of that period, the granules of various size in the body of the organism move toward the side where the pseudopod was formed. Sometimes, however, pseudopods are formed simultaneously in two or three places. Then they all begin to get smaller and the body of the ameba remains in an unchanged position. Or there is but one pseudopod, and when it has attained a certain size it begins to become smaller without the body of the organism having moved. Several times I measured the rapidity with which an ameba changed position, but found that this commonly varies; but it can be said that in one minute the body travels approximately from 0.001 to 0.003 mm. The amebae which I observed in infusions traveled in the same time as a rule considerably greater distances, although their bodies are not larger than that of the ameba of my own mouth. Probably this depends on the lower consistence of the infusions, since as the fluids evaporate the amebae begin to move more slowly. All the amebae which I have encountered in the soft white substance invariably present pseudopods of rounded outline; acute forms I have never noted in these, although I have seen this last form several times in the amebae of infusions. In the amebae of the mouth as in all amebae there is a considerable amount of more or less granular material enclosed in the body. In the midst of these granules there are one or two larger than the rest (nucleus?).

It may be said from these observations (1) that I have found these amebae comparatively few times, only six times in eighty-three observations (about 70 per cent.); (2) they are more frequently found on the internal surface of the teeth than on the labial side; (3) the amebae have been found only in the lower jaw; (4) once I observed them even after very careful cleansing of the oral cavity.

The only points of positive statement in his verbose attempt to describe what he observed, are that Steinberg saw in soft tartar motile amebiform organisms, with a small number and rounded type of pseudopods, the body contrasting with the pseudopods by its granularity and containing coarser or globular bodies. One or other of the larg-

est of the latter he suspected was a nucleus. If he was correct in this surmise his *amiba buccalis* differs in its nucleus from that characterizing the ordinary examples of these mouth endamebae; if, as is probably the case, these coarse globules were merely remnants of ingesta, the nucleus in the parasites with which he was concerned was at least difficult to distinguish in the living organism. In the absence of direct statement it is worthless to speculate as to the size of his ameba. It is clear that the ectoplasm was hyaline and of a different "color" (refraction?) from the endoplasm, but there is no indication as to its proportionate amount save that it formed the pseudopods. It is of course utterly impossible to be positive because of the incompleteness of the description and the uncertainty of data; but at least the writers hold that these points are not incompatible with a belief that Steinberg's *amiba buccalis* was the same species of endameba as that now known and described more fully first by Prowazek under the same specific name.

In 1879 Grassi,[5] in a paper on parasitic protozoa, especially those of man, records (without illustrations) the finding of an ameba, which he named *amoeba dentalis,* in material obtained from gingivitis lesions. His brief text follows in the original:

4. *Amoeba dentalis* (mihi) (nell' uomo). E forse uguale alla *buccalis* di Steinberg (la memoria di quell' autore e rarissima e non potè consultarla neppure Leuckart). Ha molta somiglianse coll' *amoeba coli;* come essa al disotto dei 25° C. ò pochissimo mobile e tiene per lo più una forma tondeggiante; a 38° —40° C. è vivacissima e protea. Ne trovai numerosi esemplari in tre casi di ulite.

Later, however, although Perroncito also stated that he had observed these amebae twice in the mouth, Grassi doubted the verity of his observations, suggesting that the supposed amebae were perhaps "salivary corpuscles."[6] With our present knowledge there can be no doubt that Grassi's observation of amebae in the human mouth was correct; and the points in his brief notice that are especially noteworthy are that the parasites were obtained from cases of gingival inflammation (probably pyorrhea) and that they much resembled *ameba coli.* (This last statement, it must be remembered, was made before the present separation of the old species *a. coli* into *Endameba coli,* and *Endameba histolytica* obtained.) It is very significant, too, that by Grassi's counsel, and more or less under his direction, the dentist Chiavaro in 1914 devoted a study to *Endameba buccalis* Prowazek,[7] in which he states that "probably *Entameba buccalis*

5. Grassi: Gazzetta med. Ital.-Lomb., vol. 39 (8th series, vol. 1), p. 446; Nov. 8, 1879.

6. Grassi: Cf. Railliet, Traité de Zool., méd. et agricole, Paris, 1895, p. 118.

7. Chiavaro: v. sup. for abstract; original, Ricerche sull' Entamoeba buccalis, Lavoro eseguito nel R. Instituto di Anatomia Comparata della Università di Roma diretto dal Prof. B. Grassi, Roma, 1914.

described by Prowazek should be identified with *amoeba gingivalis* Gros (1849), with *Entameba buccalis,* Steinberg (1862), with *Amoeba dentalis* Grassi (1879) and with the ameba found by Flexner in 1892 in Baltimore in an abscess of the lower jaw." Under such circumstances there seems little reason for extended discussion, and the writers accept in full the identity of Grassi's organism with that of Prowazek.

In 1904 Prowazek[8] announced his discovery of a parasitic ameba of the human mouth, under the name of *Entamoeba buccalis,* without reference to the earlier work above detailed, and repeating for his declaredly new species a name previously appropriated by Steinberg for an organism of the same genus and of the same habitat. His article is easy of access and forms the basis for the texts of prevailing works upon animal parasitology, and is confirmed in the writings of other observers;[9] for which reasons there is no need of detailing here more than the important data included in his original article. He met these organisms in material from the cavities of decayed teeth, first in Rovigno and later in several individuals in Trieste. He describes them as varying from 0.006 to 0.032 mm. in diameter when at rest; provided with a distinct ectoplasmic border, hyaline and refractive; a granular endosarc full of food vacuoles and ingested globular masses; mononucleated (the nucleus commonly deep in the body, small, 0.0015 to 0.0045 mm. in diameter, round, vesicular, poor in chromatin, with small, deeply chromatic "binnenkörper," a thick nuclear membrane refractive and of greenish tint and often showing chromatin granules collected along its inner limit); the whole nucleus of firmer consistence than that of *Endameba histolytica* Schaudinn and not compressible by the coarse ingested masses in the endosarc; endowed with active motility; pseudopodia few, broadly lobose and rounded, but sometimes forming an elongation of the animal as a single broad pseudopod; without contractile vacuole. He speaks of the frequent presence of residua of leukocytic nuclei in the nutrition vacuoles; and describes reproduction by simple division after nuclear swelling, mitotic changes in the binnenkörper and division of the nucleus. He also calls attention to what he believes to be chromidia of nuclear origin in the cytoplasm, which he suggests may develop into complete nuclei of young amebae (which then separate from the parent by gemmation); but at time of publication he has not met evidence of reproduction encystment. He recognizes a general resemblance to *Endameba coli* (Lösch) and *Endameba histolytica* Schaudinn, but dif-

8. Prowazek: Arbeiten aus d. Kais. Gesundheitsamte, vol. 21, p. 42.

9. Cf. Leyden and Löwenthal: Charite Annalen, vol. 29, p. 3, in a case of cancer of mouth.

ferentiates it from the former by its clearer and complete hyaline ectosarc and by the differences in the observed modes of reproduction; and from the latter mainly by the greater rigidity of its nucleus and more definite structure of the nuclear membrane.

These characters in a general way the writers can corroborate, but in some points would insist upon a greater latitude of variation than the outline given above would indicate. And in fact Prowazek in his article, in commenting upon the completeness of the ectosarc, specifically indicates much variation in its thickness; and, in speaking of the rigidity of the nucleus, acknowledges that in rare instances when it is, as occasionally may be noted, in eccentric position, close to the ectosarc, it may show indentation in the varying movements of the animal. Leyden and Löwenthal[9] who identify their organisms with that described by Prowazek vary from his statements as to the size (0.008 to 0.020 mm.) of the organism, the uniformity of distinction of ectosarc and endosarc and as to the position of the nucleus (sometimes at border of endosarc and ectosarc but usually central); and they fail to recognize in the living animal the peculiar greenish shimmer mentioned by Prowazek in the nuclear membrane, suggesting the operation of the personal equation in the observation. In our earlier papers upon this subject the writers have held that of the endamebae of the various cases of pyorrhea examined all but one or two (tentatively held as *Endameba kartulisi* Döflein) were examples of *Endameba buccalis* Prowazek, but suggested that perhaps fuller study might indicate that of the larger group some should be referred to a third, unidentified species. This last point was based upon the fact that occasional examples varied beyond the usual size, attaining as much as 0.038 or 0.04 mm diameter, that these were apt to show a greater general activity of movement, and often extruded unusual numbers of pseudopods and these of unusual shapes (often small drop-like projections, or small projections of the same type upon the border of the main pseudopods). Further study has led us to believe these features are not of specific differentiating value, and as the other characters, studied in the stained specimens, are identical we are of the opinion that such forms are merely exceptional individuals of one general species. While in a given material some examples may have attained the size mentioned, the greater number were smaller; and while in a given observation a greater activity of the amoebae of a certain individual was noted, a second preparation on the same or a subsequent day from the same person has repeatedly failed to show the same degree of motility. And in one and the same ameba we have repeatedly seen alternate periods in the course of a brief observation of the living animal when the pseudopods would vary from one or two large,

rounded lobose projections, to longer and digitate types, to be succeeded perhaps in a short while by numerous small drop-like projections of the ectosarc. For such reasons we are satisfied occasional variations, even if marked, cannot be insisted upon for specific identification, and that only the common type, as the mean number, size and form of the pseudopods, should be held as of value in this connection. With this preface our description of these parasites may be outlined as follows: Naked parasitic amebae of usual diameter in resting examples of 0.030 to 0.035 mm. (with exceptional instances reaching 0.040 or slightly above); with refractile and faintly greenish-tinted hyaline ectosarc well defined from the granular endosarc, but sometimes so thin as to be easily overlooked; endosarc granular, colorless and in all but the more minute examples containing few to many digestion-vacuoles in which globular detritus of leukocytic nuclei and red blood cells are commonly found along with bacteria; with a small (0.002 to 0.005 mm.) rounded nucleus, invisible or at best uncertainly distinguishable in the unstained specimen, usually central or subcentral in position (Fig. 3; a, b), but at times eccentric (when the ingesta push it to one side) (Fig. 3; c, d, e). The difficulty of distinguishing the nucleus in the living animal prevents the writers from expressing a positive opinion as to its greater rigidity than that possessed by the nucleus of *Endameba histolytica* Schaudinn, but we have certainly met in stained specimens oval and slightly indented nuclei which makes us hesitate to accept this point which Prowazek especially indicates as distinctive from the dysentery endameba (Fig. 3; f, g, h). The nucleus is very poor in chromatic substance, vesicular, with a small "binnenkörper," sometimes showing a minute centriole, a clear space between it and the nuclear border containing no chromatin or at most a very few incomplete threads; and the border is represented by a thin but somewhat irregular line of chromatin, about which the writers are unable to recognize a further membrane and which they regard as the membrane itself. The thickness of this membrane is not absolutely fixed, sometimes more delicate, sometimes less so, but always thin, with scattered parts thicker than others or with scattered chromatin granules on its inner surface (Fig. 4). The degree of motility manifested by the parasites is to us fairly comparable to that of the dysenteric endameba (Fig. 5). The pseudopods as a rule are few (one, two, or three), usually broadly lobose and commonly attaining a maximum length of the diameter of the endosarc. Not infrequently a single extension may reach even a greater length, making the full long measurement of the parasite 70 or more micromillimeters. Or occasionally there are more pseudopods, these then small and guttulate. The pseudopods are composed practically entirely of the ectosarc, the granular endosarc terminating

at the base, or extending but a little into the larger ones. We have observed examples containing two nuclei (Fig. 3; i) and have seen binary division of the living ameba take place; and have repeatedly seen small protoplasmic masses separate by gemmation (some of these containing minute particles of chromatin); although we are uncertain as to definite chromidial formation, as we are confused by bacteria and bacterial fragments which are numerous in the larger amebae and which stain very like the chromatin with Giemsa stain and with iron-hematoxylin which we have usually used for study. We have found "dauer" cysts, but thus far no reproduction cysts.

With these data in hand the writers do not hesitate, in spite of the published differences (which we believe are due to nonspecific variations), to identify the organism with which we have become fairly familiar, with that of Prowazek. As above indicated, we see no reason to believe the *Ameba dentalis* of Grassi to be other than the same species, if we may accept identity of habitat, identity of lesion, comparable morphology (as expressed in terms of the dysenteric endameba), and the evident later opinion of Professor Grassi as to identity (inferable from his relation with Chiavaro's paper). It is impossible to be sure of Steinberg's *Amiba buccalis;* but identity cannot be denied or specifically asserted. The *Amoebea gengivalis* of Gros is so nearly like the same organism, as shown by his drawings and a few points in the text, that it is impossible to say it is not the same and quite within reason to say that it probably is identical. Gros may therefore be held as probably the original observer of the common oral endameba with which we are today familiar; and by rule of priority, with modification of spelling of *gengivalis* to *gingivalis* to conform with etymological propriety this organism should take the nomenclature *Endameba gingivalis* (Gros) instead of the more common present-day name *Entameba buccalis* Prowazek. In this attitude in fact the writers are not the first.[10]

In addition, the writers feel that further attention should be given to certain amebae which have been met by Kartulis,[11] Flexner,[12] Verdun and Bruyant[13] and Bruyant and Pelissier[14] in the same comparative lines. The first and second refer to amebae met in the pus of abscesses of the lower jaw, the third to organisms in the pus of two symmetrical abscesses of the cheeks, and the

10. Brumpt: Précis de Parasitologie, 1st and 2d editions, Paris, 1910 and 1913.

11. Kartulis: Ztschr. f. Hygiene, 1893, vol. 13, p. 9; and Kolle u. Wassermann: Handb. d. pathogen. Mikroorg., 1st ed., 1907, vol. 1, p. 356.

12. Flexner: Johns Hopkins Hosp. Bull., November, 1892, vol. 3, p. 104.

13. Verdun and Bruyant: L'Echo méd du Nord., Aug. 11, 1907, vol. 11, p. 375.

14. Bruyant and Pelissier: L'Echo méd. du Nord., June 29, 1909, vol. 13, No. 26.

fourth to amebae in pus from suppurative gingivitis. Flexner's ameba was regarded by himself as indistinguishable from the dysenteric ameba (*endameba histolytica?*), an organism apparently with no marked dis-distinctness of differentiation between the homogeneous ectosarc and the granular endosarc, the latter containing numerous vacuoles and showing in its interior red blood cells and their detritus. The nucleus was not recognized in the living cell; the pseudopods were characteristically blunt, varying from a mere bulging to a change in which the greater part of the ameba was protruded. No actual measurements were published by the observer, and no drawings accompany the text. It is usually classed as *endameba Kartulisi.* General conformity to the characters above indicated for *Endameba gingivalis* (Gros) seems to the writers, however, to be included in these incomplete data. That *Endameba gingivalis* (Gros) may be met in such maxillary abscesses the writers can testify positively on the basis of two cases. One of these occurred secondarily to alveolar fracture occurring in the extraction of a carious tooth, and was accompanied in its course of three or four years by the discharge of sequestra from the jaw and extension of the suppuration to the surrounding soft parts in the cheek and floor of the mouth, with establishment of an external fistula. At the time of discovery of the amebae in this case the fistula had healed, but sequestra were from time to time being discharged through the gingival tissues into the mouth. The mouth was kept scrupulously clean by the patient and no amebae were detected about the remaining teeth or over the exposed surface of a small sequestrum which was gradually being dislodged into the mouth; but when this was extracted numerous amebae of the ordinary *gingivalis* type were detected in spreads from its embedded surfaces. The case was treated with emetin and has promptly and completely cleared up. The second case was regarded as a dental cyst of the lower jaw, but found by the surgeon to be a chronic maxillary abscess in the pus of which the writers found large numbers of endamebae which were as a rule of larger size than usual, quite active, very commonly contained red blood cells, but on close study of stained specimens were also identified with the ameba of Gros. There seems but little reason, therefore, to regard the organisms of Flexner's case as specifically different. The impression has grown upon the writers that the ameba of Flexner became associated with that of Kartulis into an isolated species mainly because these cases of Flexner and of Kartulis were both of suppuration of the lower jaw, both published at nearly the same time and appeared before any detailed attention had been given to oral amebae, Prowazek's study not being brought forward until a decade later. Prowazek, at the close of his article above referred to, promised a further and fuller

description of his organism with differentiation from the organism of Kartulis; but the writers have failed to find this later article if it be in existence.

In 1893 Kartulis[15] announced his discovery of amebae in the pus from an abscess of the lower jaw (Fig. 6), and subsequently[16] reported similar findings in five more cases of suppurative osteomyelitis of the jaw. These organisms were named in honor of the discoverer by Döflein *Endameba kartulisi*, prior to the publication of the specific name *maxilaris*, given by Kartulis (the latter now appearing as a synonym). In all three references (*supra*) to these observations of Kartulis his first impression of similarity to the dysenteric ameba is noted. Differentiation is made because of the somewhat larger size of the organism and its higher degree of activity, both progressive and pseudopodial. In the original description, too, the nucleus is declared to be smaller and thus not comparable to the nucleus of the organism of dysentery; but it must be recalled that at the time *Endameba coli* (Lösch) was still included with the species now known as *Endameba histolytica* Schaudinn, and comparison with the larger nucleus of the former (readily observed in the unstained specimen and staining more deeply) might fairly be the cause of this statement. Kartulis describes the nucleus as small, rarely distinguishable in the unstained specimen, vesicular, and provided with an easily seen nucleolus (in stained state). It is said to be surrounded by a clear zone, referring apparently to a finely reticular perinuclear area of the endosarc. Comparing the text cuts and the colored plate illustrations of the original article by Kartulis, the diameter of the nucleus (not definitely stated) must be about 5 or 6 micromillimeters; and while in both the text cut and the colored plate it would appear to be a relatively solidly chromatic body, the "vesicular" character described indicates that the "nucleolus" is a small "binnenkörper" surrounded by a relatively clear plasm, about which a probably fairly marked nuclear wall occurs separating the intranuclear substance from the light reticular perinuclear part of the endosarc. The ectosarc is described as clearly seen in the pseudopodia, but (in the resting stage) not apparent as a peripheral zone. Both in the original text and in the cuts the pseudopods are indicated as few, large and digitate (in the later descriptions said to vary from *lobose shape* to long and comparable to the "horns" of a snail), reaching perhaps several times the length of the body diameter. If the above interpretation of the nuclear picture be correct the points of distinction from *Endameba gingivalis* (Gros) rest more particularly upon the

15. Kartulis: Ztschr. f. Hyg. u. Infectionskr., vol. 13, p. 9.

16. Kartulis: Centralbl. f. Bakt. u. Parasitenk. 1 Abt., Ref., vol. 33, p. 471; 1 Panhellen. Med. Congress in Athens, May 6-11, 1901; see also Kolle u. Wassermann, Handb. d. pathogen. Mikroorg., 1st ed., vol. 1, 1907, p. 356.

EXPLANATION OF PLATE

Fig. 1.—Photographic reproduction of that portion of the plate of illustrations accompanying article by Gros in 1849, which depicts his *Amoebea gengivalis.*

Fig. 2.—Photographic reproduction of part of plate illustrating article by v. Leyden and Löwenthal upon *Endameba buccalis* Prowazek, showing organisms in motion.

Fig. 3.—Camera lucida drawings of *Endameba gingivalis* (Gros), stained with iron hematoxylin; *a* and *b* showing the usual central or subcentral position of the nucleus; *c, d* and *e,* examples with the nucleus in eccentric position; *f, g* and *h,* examples showing nucleus in compressed condition; *i,* an example with two nuclei (it is suspected, although not known, that the small ameba lying within the same space in the stained film had been recently separated from the larger one.)

Fig. 4.—Photomicrograph of *Endameba gingivalis* (Gros), stained with iron hematoxylin; from material from pyorrhea pocket.

Fig. 5.—Composite outlines of moving *Endameba gingivalis* (Gros), including five camera lucida sketches; time included, twenty seconds; to show activity of movement and long type of pseudopod at times assumed; magnification as in Figure 3.

Fig. 6.—Photographic reproduction of a text cut of *Endameba kartulisi* Döflein from original article by Kartulis in 1894.

Fig. 7.—Photographic reproduction of text cut illustrating article in 1907 by Verdun and Bruyant, showing *Endameba pyogenes* Verdun and Bruyant.

Fig. 8.—Photographic reproduction of cut of endameba described by Ribbert, here shown in parotid duct.

Fig. 9.—*Endameba mortinatalium* Smith and Weidman, in minute hepatic abscess; stained with iron-hematoxylin.

Fig. 1

Fig. 2

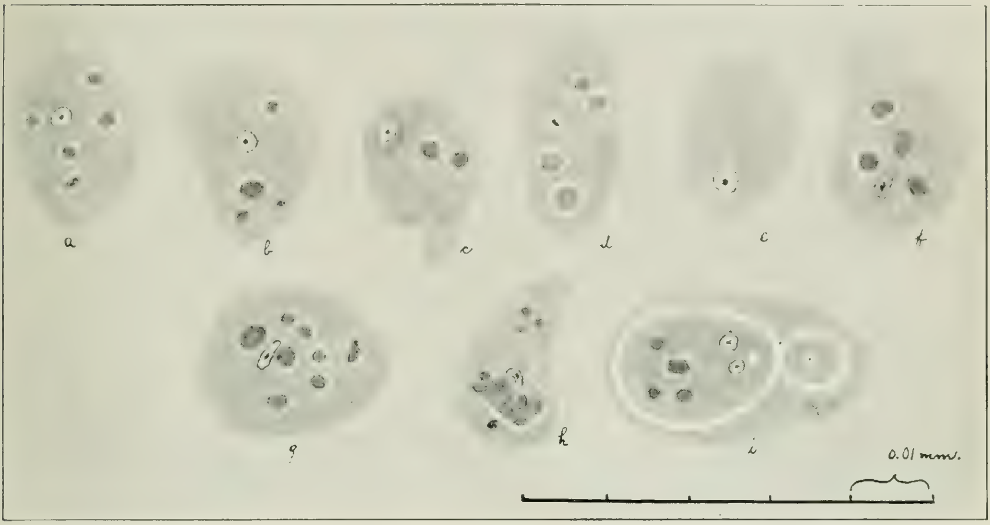

Fig. 3

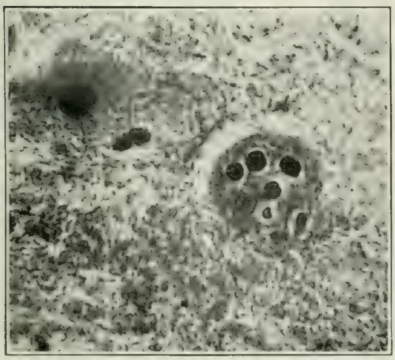

Fig. 4

Fig. 5

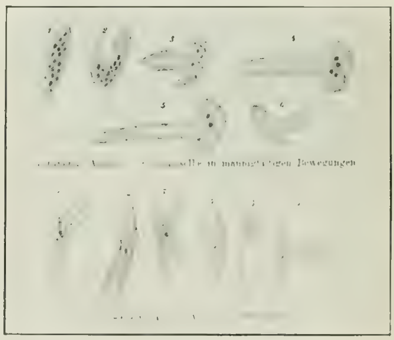

Fig. 6

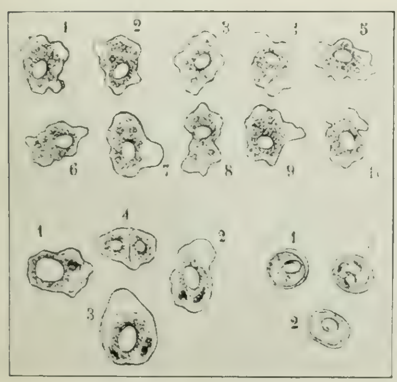

Fig. 7

Fig. 8

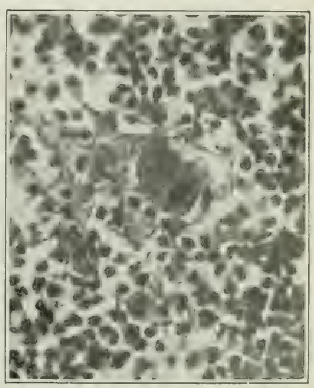

Fig. 9

size of the organism, the size and shape of the pseudopodia, the activity of movement and the lack of a clear ectosarcous border—in all of which particulars nonspecific variations of at least comparable degree may occur. Certainly in the occasional organisms which we have in the living state suspected of showing the characters of the ameba of Kartulis because of these latter points, the writers have seen the individual change and assume the general features of *Endameba gingivalis* (Gros), and subsequent study of stained examples has led us to conclude identity with the latter. We are of opinion, therefore, that there is not sufficient basis for accepting the specificity of Kartulis' type of these amebae, and would refer it also to the species *gingivalis* of Gros.

There remains of this group of parasitic amebae of the mouth for comparison the organism known as *Endameba pyogenes* of Verdun and Bruyant,[17] studied by these writers in the pus from two symmetrical abscesses of the cheeks in a case under the surgical care of Dubar and Leroy, in which there had preceded the abscesses carious teeth and pyorrhea lesions, to which the clinicians were disposed to attribute the abscess development (Fig. 7). Later Bruyant and Pelissier[18] mention the discovery of similar amebae in two cases of gingival suppuration, but with no more than partial description refer for their characters to the original article by Verdun and Bruyant. The mean diameter of these parasites is given as from 0.03 to 0.035 mm. They are described as quite active in movement, with large rounded pseudopodia rapidly projected and retracted. The pseudopods are hyaline in appearance, the endosarc granular; the ectosarcous border is not clearly seen, being absent or only visible in the pseudopods and their immediate bases. The endosarc is commonly full of digestive vacuoles in which remnants of erythrocytes and leukocytes are to be detected. The nucleus is described as relatively large, from 0.008 to 0.015 mm. (from one third to one half the diameter of the resting ameba), always visible, granular but paler than the surrounding endosarc. Double contoured cysts, from 0.006 to 0.015 mm., are described and said to frequently contain multiple, but never more than four, nuclei. Larger cysts, with single wall and a single unchanged nucleus are described, and perhaps are resistance encystments. Stained with Borrel blue and eosin, the body of the ameba is light blue, the nucleus (distinguished from the deeper blue remnants of leukocytic nuclei and copper-red residua of red blood cells about it) is apparently stained diffusely a reddish violet tint; is granular and often shows a well-defined nucleolus (binnenkörper). In brief, the size of the nucleus, its richness in chromatin

17. Verdun and Bruyant: L'Echo méd. du Nord., Aug. 11, 1907, vol. 11, p. 375.
18. Bruyant and Pelissier: L'Echo méd. du Nord., June 27, 1909, vol. 13, No. 26.

and its visibility in unstained specimens, along with the mode of reproduction within a cyst, mark this as a species of these mouth amebae distinctly different from those hitherto discussed in this paper; and as such it must be kept clearly in mind in studies of oral endamebiasis.

It is impossible to come to a definite conclusion as to the relationship of this last organism with certain other endamebae which have been described from the human body which contain large and richly chromatic nuclei because of the deficiency of data on both sides, but it may be suggested that in this connection there should be remembered certain organisms described by Smith and Weidman[19] under the name *Endameba mortinatalium,* being found by them in small abscesses in the liver and kidneys and also in the lungs of a still-born fetus (non-syphilitic). This these writers identify in a later note (October, 1910) with unnamed organisms met by Jesionek and Kiolemengolou[20] in the kidneys, liver and lungs of a syphilitic eight months fetus, and also by Ribbert[21] in the renal tubules of a syphilitic new-born infant twenty years before his publication, and twice thereafter in the parotids of nonsyphilitic infants (Fig. 8). Tietze[22] also records the discovery of amebiform organisms in a parotid tumor in a child of about 4 years of age; but these were held by Schaudinn, who examined histological sections, to be either identical to or akin to Prowazek's endameba. Smith and Weidman[23] have recently encountered the same large-nucleated ameba in the lungs of a congenitally syphilitic baby. These organisms (Fig. 9) in fixed and stained state, for the most part measured 0.025 to 0.032 mm. in diameter; the nucleus spherical or oval and usually from one third to one half the cell diameter. Considerable variation exists in the amount of ectosarc, which however in some examples is seen as a complete clear border zone in the stained examples. The endoplasm is highly granular, containing at times red blood cells and leukocytic detritus, and in some instances is full of chromidia-like bodies. The nucleus contains a very large, granular and richly chromatic binnerkörper, occasionally showing a centriole; about the binnenkörper a narrow clear zone of nuclearplasm and a delicate chromatin-staining nuclear wall, with threads or grains of chromatin scattered in the clear zone. Pseudopodia few and rounded in the stained specimens. The occurrence of these organisms in the parotid and their general comparability suggest that further study of relation be made.

19. Smith and Weidman: Univ. of Penna. Med. Bull., September, 1910.
20. Jesionek and Kiolemengolou: München. med. Wchnschr., 1904, No. 43.
21. Ribbert: Centralbl. f. allgem. Pathol., 1904, vol. 15, p. 945.
22. Tietze: Mittheilung. aus d. Grenzgebiet. d. Med. u. Chir., 1905, vol. 15, p. 303.
23. Smith and Weidman: Am. Jour. Trop. Med., vol. 2, p. 256, October, 1914.

Finally the writers (with natural hesitation because of full appreciation of the resultant confusion in our current views as to the relations of endamebae to dysentery and the impossibility of satisfactorily explaining a great field in the etiology and pathology of endamebic dysentery and its immediate complications as the liver abscess, if this statement be thought worthy of consideration) feel constrained to acknowledge that from a purely morphological standpoint we are unable to differentiate the organism which we believe to represent the vast majority of oral endamebae and to occur in an extremely large number of persons not merely in the tropics but all over the world, from *Endameba histolytica* Schaudinn. We are unwilling to make any assertion which involves biological identity in full, merely asserting that the morphological similarity is so close that we feel unable to make a distinction from microscopic observation alone. The limits of size of the two organisms are too close to permit this to serve as a specific difference; in both (Fig. 3; a, b, c, d, e) there is a tendency to clear ectosarcous differentiation from the granular endosarc in which cellular detritus and especially red blood cells and their debris may be seen; in both there is a small nucleus (the position of which is not fixed for either) of vesicular type, poor in chromatin, practically invisible in the unstained specimen, and showing the same small binnenkörper, the same plasmatic space between the latter and the nuclear border, which is formed by a delicate but variably irregular and chromatic nuclear membrane; both show few pseudopodia characteristically, and these usually of broad lobose type; and the general type of motility of both the cell and the pseudopods is closely comparable in the main but variable in both. Both forms, too, divide by binary fission and by gemmation,[24] both fail to form reproduction cysts as far as is known. And if it be a characteristic of *Endameba histolytica* Schaudinn to destroy red blood cells, so, too, is *Endameba gingivalis* (Gros) capable of rapid digestion of these same elements. We have repeatedly watched the complete disappearance of freshly englobed erythrocytes in the living ameba of Gros, the red cell fading before our eyes to invisibility in from three to five minutes.

Prowazek in his original article compares his ameba, which we have above held to be identical with *Endameba gingivalis* (Gros) with

24. *Note by Editor:* Gemmation, as a form of division in *E. hystolytica,* has been proved not to occur, the so-called gemmation being due to degenerative changes. In *E. histolytica* reproduction cysts occur, of course; the four-nucleated cyst of this species being easily distinguished from the eight-nucleated cyst of the harmless *E. coli.* If it be true that reproduction cysts do not occur in *E. gingivalis,* this alone would serve to distinguish this species from *E. histolytica.* Likewise the *tetragena* type of nucleus of *E. histolytica* does not occur, according to the author's description, in *E. gingivalis.*

Endameba histolytica Schaudinn, acknowledging its close conformity, but differentiating it by the point that its nucleus is more rigid, less likely to present compressed, flattened outlines. Such a point is exceedingly questionable; nuclear deformation may depend as much upon the amount and rigidity of ingested substances and the movement pressure of the cell as upon any special nuclear consistence. Prowazek from his text gives the impression that this is best appreciated in the living and moving organism; but it is difficult to observe the nucleus of either one in this state. Occasionally at least the writers have met slightly indented and oval nuclei in stained specimens of *Endameba gingivalis* (Gros).

Even if this suggestion be refused, the writers feel there is need of a more easily demonstrable differentiation, and believe that more than merely morphological studies are requisite to prove the dual specificity.

ACANTHOCEPHALA IN NORTH AMERICAN AMPHIBIA *

H. J. Van Cleave

A careful search of the literature has revealed but a single instance in which Acanthocephala have been found parasitic in North American Amphibia. Stiles and Hassall (p. 352) record the occurrence of Acanthocephala in *Diemyctylus viridescens,* Raf. taken in Maryland by Dr. Hassall, though no determination of the species is given in the work cited. Through the courtesy of Dr. B. H. Ransom of the U. S. Bureau of Animal Industry the writer has been permitted to study these undetermined forms. The label accompanying this collection of seven worms bears the additional information that the host was taken at Franklin Falls, Baltimore, Md., in May, 1893, and that they were from the intestine. The location of the brain (Fig. 1) at the base of proboscis sheath, together with the fact that the retinacula proceed directly from the posterior end of the sheath give sufficient data for ascribing these specimens to the genus *Acanthocephalus* Koelr. Further the writer has determined them as belonging to the species *A. ranae* (Schrank).

The recent work of Lühe (1912) upon variability in the number of proboscis hooks in this species has led the writer to make a study of this point in the material at hand. In forty-three specimens collected from the same locality Lühe found the number of longitudinal rows of hooks varied from thirteen to nineteen (1912, p. 297), while the number of hooks in each row varied within the limits of four and six. Some individuals had rows of four hooks alternating with rows of five, some had five in each row, some had rows of five hooks alternating with rows of six hooks, while still others had six hooks in each row. Of the seven individuals of the American form which the writer has studied, four have the proboscis fully protruded. In every one of these the proboscis is armed with twelve rows of hooks and there are six or seven hooks in each row. These numbers agree precisely with the data given by Porta (1908, p. 228) for the hooks of *A. ranae* (Schrank). Unfortunately Porta does not give measurements for the hooks of the form he described under this name. He describes the embryos as being 0.07 to 0.09 mm. in length while Lühe (1911) records a length of 0.11 mm. and

* Contributions from the Zoological Laboratory of the University of Illinois, under the direction of Henry B. Ward, Urbana, Ill., No. 45.

a breadth of 0.013 mm. for embryos of *A. ranae* from Germany. If the two authors are describing the same species there is far greater range of variability in the size of the embryos of this species than has come to the attention of the writer in a study of embryos of many species of Acanthocephala from the United States.

A comparison of hook lengths in the American form with Lühe's data for *A. ranae* from Germany is given here, following Lühe's method of designating each hook. Since the hooks in two adjoining longitudinal rows alternate, those in the longest row are numbered from the tip posteriad: 1, 3, 5, 7, etc., while the hooks in the adjacent row are: 2, 4, 6, 8, etc. Lühe's measurements are for but a single row.

Hook Lengths in Acanthocephalus Ranae (Schrank)

Hook	American Form	German Form Data from Lühe
1	59μ	60μ
2	71	..
3	71	70
4	71	..
5	71	75
6	77	..
7	77	80
8	77	..
9	77	75
10	71	..
11	71	50
12	53	..
13	30	—

Attention should be called to the fact that in representatives of this species found in North America the basal hooks in some rows are very much shorter than the basal hooks in the row adjoining (cf. 12 and 13 above).

Inasmuch as Lühe has found such great variability in numbers of hooks in *Acanthocephalus ranae* it is not beyond reason to expect that in his relatively small number of individuals (43) he did not include the full range of variability. The writer supports Porta's record of twelve longitudinal rows of hooks. The depression of Lühe's lower range of variability for number of longitudinal rows of hooks by one, and the extension of his upper range of the number of hooks in each of these rows similarly by one, are thus within the bounds of variability in this species. It was in view of these facts that the writer found it necessary to ascribe the specimens of the single North American collection of Amphibian Acanthocephala to the species *Acanthocephalus ranae* (Schrank). Unfortunately none of the specimens contained fully formed embryos. For that reason measurements of embryos had to be omitted from the all too few

sources of data of value in the determination of species in the Acanthocephala.

The fact that there has been but one published record of Acanthocephala in Amphibia of North America led the writer into an investigation to determine whether this might be due to inadequate study and records of Amphibian parasites in this country or to a comparatively infrequent infestation of Amphibians with parasites of this class. The writer, personally, has records of the examination of over one hundred fifty Amphibia for parasites, chiefly from Illinois, none of which harbored Acanthocephala. The records of Leidy's extensive researches in parasitology, while including many references to other forms parasitic in Amphibia, contain no mention of Acanthocephala in that group. Dr. H. B. Ward has very kindly granted permission to include results of the examination of about fifty Amphibia contained in the records of his parasitological col-

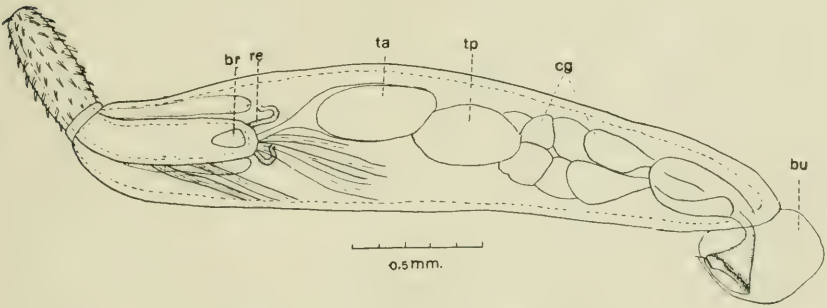

Fig. 1.—Acanthocephalus ranae (Schrank). Toto mount ♂. Stain, Ehrlich's Acid Hematoxylin. Damar mount; br, Brain; re, Retinacula; ta, Anterior testis; tp, Posterior testis; cg, Cement glands; bu, Copulatory bursa.

lection. His materials represented collections from seven different states in the central and western United States. His records indicate the absence of Acanthocephala in all Amphibia examined. The writer is also indebted to Dr. George R. La Rue who very kindly furnished data from the records of his collections. In over one hundred and thirty hosts, including numerous species both of Urodela and of Anura from six different states, including eastern, central, and western states, La Rue found no Acanthocephala. From all sources, then, the writer has data showing the absence of Acanthocephala in above three hundred specimens of Amphibia distributed in the following states: Illinois, Michigan, Kansas, Nebraska, Ohio, Pennsylvania, North Dakota, Oklahoma, and Missouri. Such a condition stands in marked contrast to the records of European investigators who have recorded several species of Acanthocephala from Amphibia with many cases showing high percentages of infestation. Thus, for

example, Mühling (p. 55) found 50 per cent. of *Rana esculenta* infested with *A. ranae* (= *E. haeruca*). European Amphibia also serve as intermediate hosts for larval Acanthocephala which attain maturity in the intestine of birds. *Corynosoma semerme* and *Centrorhynchus aluconis* both pass their larval stage in European Amphibia. So far no larval Acanthocephala are known in North American Amphibia.

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THE PROTECTION OF PARASITES IN THE DIGESTIVE TRACT AGAINST THE ACTION OF THE DIGESTIVE ENZYMES

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In carrying out an investigation on the rate of oxidation of enzymes and their corresponding pro-enzymes it has been necessary to make use of many dogs for collecting pancreatic juice and preparing secretin and enterokinase. Tapeworms and roundworms were found in the intestines of many of these animals and the question so often raised presented itself, viz., why is it that these worms are not digested by the trypsin? Various explanations have been offered in answer to this question, such as the existence of an antisubstance in the worm which inhibits the action of the trypsin, or the resistance of the cuticle to the activity of the enzyme or the fact that the parasites are alive, etc. Lillie and others have shown that the mucosa of the stomach and intestine possesses intense oxidative properties and Burge has found that trypsin, in common with all the digestive enzymes, is relatively easy to oxidize. On the basis of these two facts we have advanced an hypothesis according to which the mucosa of the digestive tract by means of the oxidative processes going on in its cells is able to maintain its integrity during life by rendering inactive the enzyme solution immediately in contact with it. This assumes that there are two opposing activities at work, viz., the active enzyme within the lumen of the digestive tract attempting as it were to digest the cells of the mucosa, while the oxidative processes of these cells are rendering the enzyme inactive and hence protecting the mucosa from digestion. The same explanation might be given for the fact that parasites are able to live in the intestinal juices without being digested. The assumption is that the oxidative processes going on in the cells of the parasite exposed to the action of the trypsin are oxidizing the enzyme. Thus the parasite, like the mucosa of the tract itself, is protected from digestion.

The following experiments and observations were made to determine if any experimental evidence could be brought forward in support of this assumption:

A dog was etherized and killed with chloroform. The intestine of this animal was slit open and the tapeworms and roundworms removed. The duodenum and several inches of the intestine following were thoroughly washed and the mucosa gently scraped with the handle of a scalpel. Enterokinase was prepared by extracting this scraping with 0.7 per cent. sodium chlorid. The

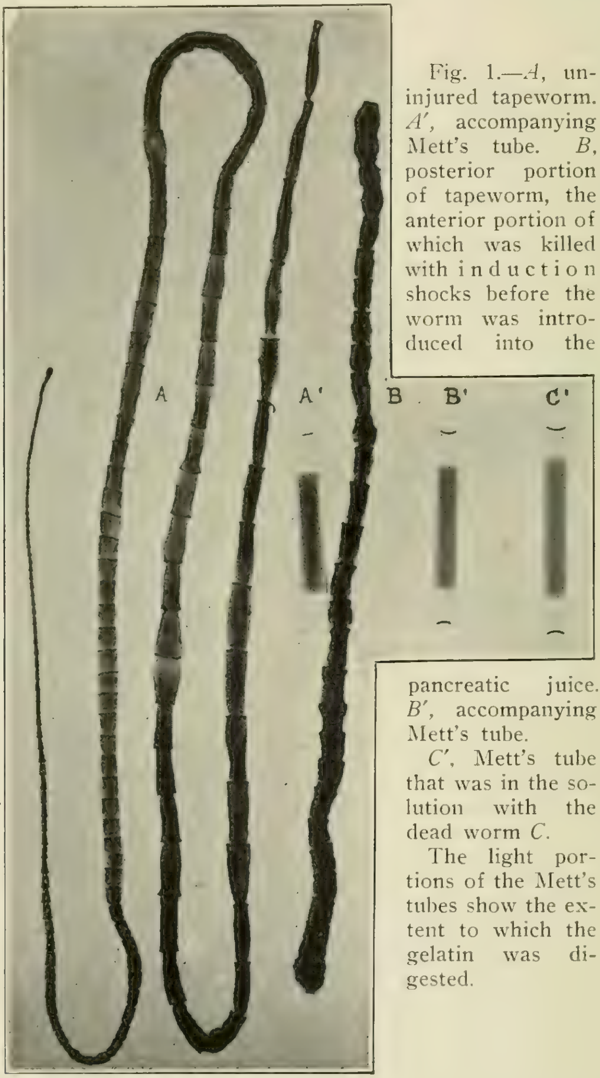

Fig. 1.—*A*, uninjured tapeworm. *A'*, accompanying Mett's tube. *B*, posterior portion of tapeworm, the anterior portion of which was killed with induction shocks before the worm was introduced into the pancreatic juice. *B'*, accompanying Mett's tube.

C', Mett's tube that was in the solution with the dead worm *C*.

The light portions of the Mett's tubes show the extent to which the gelatin was digested.

secretin was prepared by extracting the hashed mucosa with 200 c.c. of 0.4 per cent. hydrochloric acid. This extract was boiled and neutralized while boiling with 1 per cent. sodium hydroxid. On filtering a perfectly clear solution was obtained. This secretin was injected into the jugular vein of an etherized dog and approximately 100 c.c. of clear pancreatic juice were obtained from the pancreatic duct.

Thirty c.c. of this pancreatic juice were activated by the addition of 3 c.c. of enterokinase. This trypsin solution was sterilized by exposing it for five minutes to the radiation from a 2,400 candle power quartz mercury vapor burner at a distance of 12 cm. A tapeworm, *Taenia serrata,* about 40 cm. in length, was washed in tap water, rinsed in distilled water, and introduced into 10 c.c. of the solution. Another tapeworm of about the same size was selected and one electrode from the secondary of a large induction coil was placed near its anterior end while the other electrode was moved back and forth over the anterior half of the parasite until no response to stimulation was obtained from this portion. In this manner the anterior part of the tapeworm was killed without breaking the cuticle. A third worm of similar size was selected and the entire worm killed by means of induction shocks. These worms were placed in vessels containing 10 c.c. of the activated pancreatic juice. The three vessels containing the worms were allowed to stand at room temperature for twelve

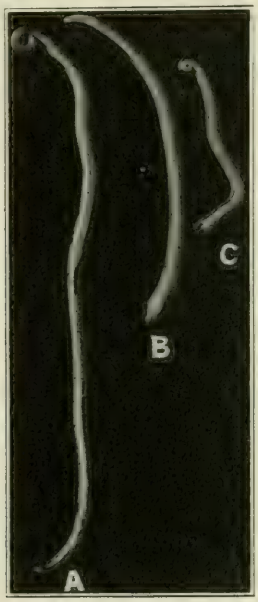

Fig. 2.—*A,* uninjured roundworm. *B* and *C,* undigested halves of two worms, the dead halves having been digested.

hours. At the end of this time the uninjured worm and the uninjured half of the other worm were stimulated by means of weak induction shocks. It was found that they were alive. These solutions were removed and 10 c.c. of fresh sterilized juice introduced into each vessel. At the end of the second twelve-hour period the anterior portion, which had been killed with induction shocks, as well as the entire worm which had been killed in the same manner had begun to be digested. After introducing into each vessel 10 c.c. of fresh juice the worms were permitted to stand for a third twelve-hour period. Thus the parasites were exposed to the action of the trypsin for thirty-six hours. Figure 1 shows the condition of the parasites at this time. *A* is the uninjured tapeworm; *A′*, a Mett's tube containing gelatin colored with Congo red which was placed simultaneously with the worm in the pancreatic juice in order to give an idea of the strength of the trypsin. The dark portion of the tube represents

the undigested gelatin and the light the empty tube from which the gelatin was digested. *B* is the worm the anterior part of which was killed with induction shocks, *B′*, its accompanying Mett's tube. *C′* is the tube which was in the solution with the dead worm *C*. It may be seen that no portion of the normal worm *A* was digested, that the dead portion of *B* was completely digested as was also the dead worm *C*.

Similar experiments were carried out using roundworms. Halves of roundworms were killed by means of induction shocks and these together with an uninjured worm were introduced into 15 c.c. of activated pancreatic juice, sterilized by ultra violet. The vessel containing the juice and the worms was placed in a thermostat at 38 C. At the end of ten hours the solution was replaced by 15 c.c. of fresh juice. At this time digestion of the dead portions had begun. The uninjured worm and the uninjured portions of the other two were still alive. At the end of the second ten-hour period the dead portions of the worms were almost completely digested. The juice was again changed and at the end of the third ten-hour period the uninjured portions were completely digested. A photograph of the worms was taken at this time (Figure 2); *A*, is the uninjured worm; *B* and *C*, the undigested halves of the two worms, the dead halves having been digested.

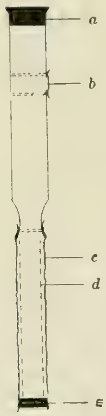

Fig. 3.—*a*, pipette closed with stopper; *b*, oneway valve; *c*, segment of round worm; *d*, platinum mesh; *e*, thin rubber and ligature.

The experiments now to be described were devised to show that the uninjured parts as well as the uninjured worms were not digested because of the protection afforded by the oxidative processes going on in them. Two segments, each 5 cm. in length, were cut from a roundworm. Into the lumen of one segment (Fig. 3, *c*) was introduced a cylindrical piece of platinum mesh (*d*) previously covered with platinum black. Around one end of the segment was wrapped a narrow strip of thin rubber (*e*) about which a ligature was tied thus closing this end of the segment. A pipette (*a*) was inserted into the open end. This was held in position by means of a ligature. The segment was filled with hydrogen peroxid through the pipette, the pipette stoppered and a one-way escape valve (*b*) arranged so that the oxygen liberated from the hydrogen peroxid by platinum black could not escape from the segment through the pipette until the pressure reached approximately 25 mm. of mercury. The pressure arising from the liberated oxygen forced it through the body wall of the roundworm. In this manner all parts of the roundworm were exposed to oxygen presumably in a nascent state. At this stage of the experiment the segment of the worm was dead and the only processes going on within it in

any way comparable to any of the living processes, was the artificial oxidative process. One end of the other segment cut from the same roundworm was ligatured and the segment filled with a solution made by decomposing hydrogen peroxid with platinum black. The other end was closed by a ligature and the preparation introduced into the activated pancreatic juice along with the other preparation. The vessel containing the preparations was placed in a thermostat at 38 C. and allowed to remain for forty-eight hours. At intervals of two hours fresh hydrogen peroxid was introduced into the segment into which the pipette was tied. At the end of twenty-four hours the pancreatic juice was removed from the vessel and fresh pancreatic juice added. At the end of forty-eight hours there was very little if any indication of digestion in the segment which was permeated by oxygen while the other segment was digested. The conclusion is drawn that nascent oxygen prevented the segment of the worm from being digested by rendering inactive the enzyme solution in contact with it.

SUMMARY

Tapeworms and roundworms from the intestine of the dog are not digested when introduced into activated pancreatic juice so long as they remain alive but are digested when dead. If any part of them be killed this part is digested.

A dead roundworm which is ordinarily digested when introduced into activated pancreatic juice, can be prevented from being digested by keeping the dead body wall constantly permeated with nascent oxygen.

The oxidative processes of the living parasites enable them to withstand the action of the digestive juices by oxidizing the enzyme solution immediately in contact with them.

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PARASITES OF THE AMERICAN MUSKRAT (*FIBER ZIBETHICUS*) *

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In previous papers[1] the finding of a varied and abundant parasitic fauna in muskrats in Nebraska was announced, and attention was called to the fact that with the exception of a brief note by Leidy[2] there are no references to or descriptions of the parasites of the muskrat. Those papers reported the finding of seven new species of trematodes, one new species of cestode, and two new species of nematodes. In more recent investigations, two additional species of trematodes, one species of cestode and one species of nematode have been found.

A recent appeal to American helminthologists in the Journal of Parasitology by Prof. Al. Mrazek further emphasizes the lack of information concerning the parasites of the muskrat and the desirability of more extensive data. For these reasons it has seemed advisable to publish at once this preliminary description of the parasites which we have found in American muskrats and later the more detailed descriptions.

The forms recorded by others are the following:

Leidy[2] mentions finding a number of trematodes in the small intestine of the muskrat which he placed in *Echinostomum echinatum* Zeder. He also found in the muskrat two specimens of a trematode which he says "appear to belong to *Amphistomum subtriquetrum* Rud." We question the correctness of the diagnosis of this trematode and suspect that they were specimens belonging to the new genus and species *Wardius zibethicus.*

Dr. B. H. Ransom reports an unidentified species of Filaria from the muskrat in the collection of the Bureau of Animal Industry, Washington, D. C.

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The forms which we have discovered are as follows:

TREMATODES

Echinostomum coalitum Barker and Beaver, *sp. nov.*[3] (Plate 1, Fig. 1).

Twenty-two specimens of an unusually large trematode were found among several hundred specimens of different species of trematodes in the intestines of forty-six muskrats. The condensed description of this species based on the specimens obtained is as follows:

Body much elongated, flattened dorso-ventrally, tapering posteriorly, slightly tapering anteriorly. When alive, color reddish or creamy, body very flabby. Length 22 to 30 mm., width at level of ovary 1.5 to 2.3 mm., at level of acetabulum 1 to 1.4 mm. Anterior part of body covered with minute spines. Well-defined reniform collar surrounds oral sucker. Collar has wide shallow or deep narrow indentation in posterior edge of ventral surface and bears 35 spines arranged in single or slightly alternate rows, 25 large spines on rim and 5 smaller spines on each lappet. Oral sucker circular, terminal, 0.37 to 0.46 mm. in diameter. Acetabulum at level of second anterior sixth of body, pouch like, strongly muscular, 1.37 to 1.60 mm. long by 1.12 to 1.32 mm. wide. Opening of sucker circular, very large, 0.72 mm. in diameter. Mouth and pharynx separated by tubular non-muscular prepharynx, 0.2 to 0.3 mm. long. Esophagus 1.03 to 3.2 mm. long. Intestinal ceca tubular, slightly undulating, increasing in caliber toward posterior end of body where they end blindly. Testes close together in median plane, at third fourth of body, one testis directly behind other; elliptical; anterior testis entire to four-lobed, posterior with smooth or undulating margin. Cirrus pouch large, gourd-shaped, with base to right or left at level of anterior third of acetabulum. Cirrus pouch encloses tubular, U-shaped seminal vesicle, voluminous granular prostate gland and large muscular-walled cirrus. Genital pore a little anterior to anterior margin of acetabulum.

Ovary ovoid, margin smooth or undulating, transverse, median, in anterior part of posterior half of body. Shell gland well defined, posterior to ovary and slightly larger than it. Seminal receptacle and Laurer's canal not evident. Yolk glands voluminous, of small spherical follicles, masses continuous, in lateral areas, extending from slightly caudad to acetabulum to extreme posterior end of body where they coalesce in the median plane, completely filling body posterior to testes. Transverse vitelline ducts and reservoir present at level

3. Abstract of unpublished research by Franklin D. Barker and Chester A. Beaver.

EXPLANATION OF PLATES

All drawings were made with a camera lucida from original specimens. The degree of magnification is indicated by a vertical line 1 mm. in length at the side of each figure.

Abbreviations

A D, Adhesive disc
Ac, Acetabulum
B C, Bursa copulatrix
C P, Cirrus pouch
Cr, Cirrus
Es, Esophagus
Ex, Excretory reservoir
G P, Genital pore
G Pa, Genital papilla
L C, Laurer's Canal
Ov, Ovary
P S, Posterior sucker
S, Sucker
S G, Shell gland
S R, Seminal receptacle
S V, Seminal vesicle
T, Testis
Ut, Uterus
Va, Vagina
V D, Vas deferens
V G, Vitelline glands
V R, Vitelline reservoir

PLATE 1

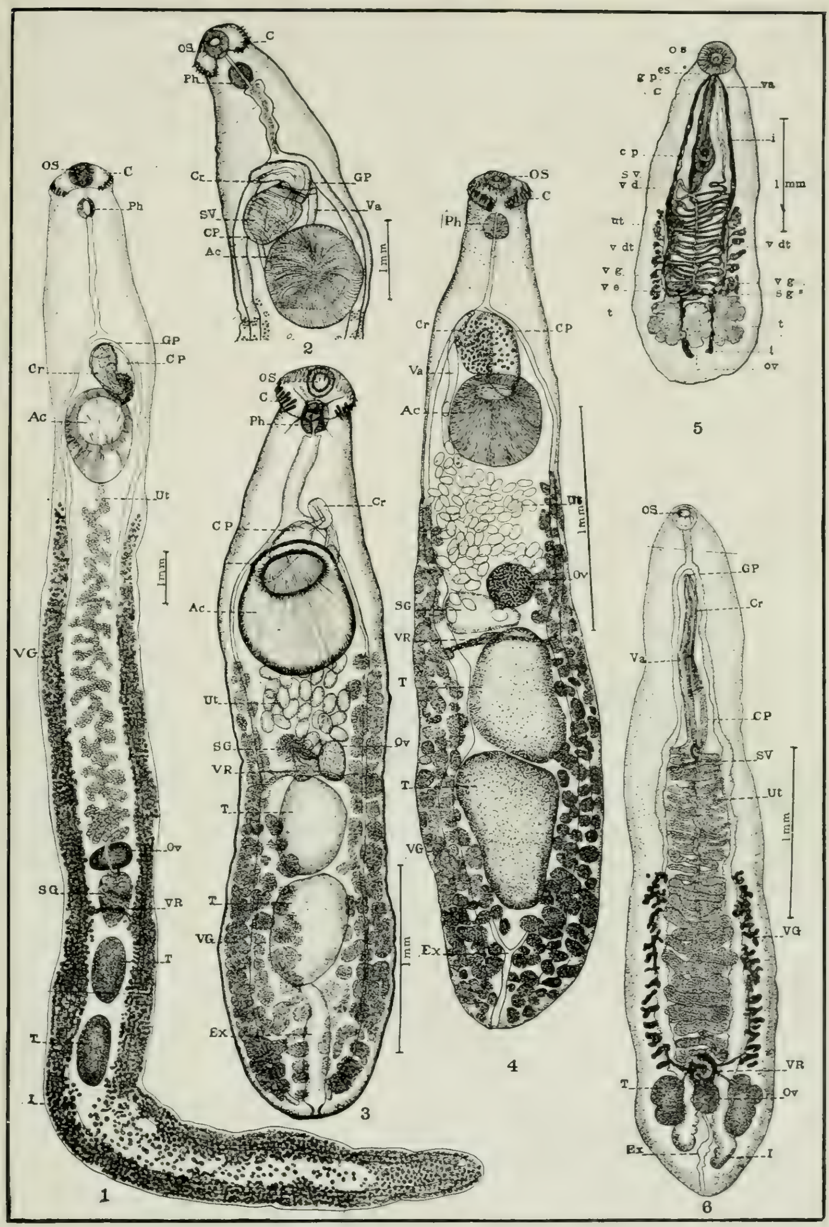

Fig. 1.—*Echinostomum coalitum* Barker and Beaver, ventral view, specimen slightly compressed.

Fig. 2.—*Echinostomum coalitum,* anterior end enlarged to show cirrus pouch and contents.

Fig. 3.—*Echinoparyphium contiguum* Barker and Bastron, ventral view, specimen compressed.

Fig. 4.—*Echinostomum callawayensis* Barker and Noll, ventral view, specimen compressed.

Fig. 5.—*Notocotyle quinqueseriale* Barker and Laughlin, ventral view.

Fig. 6.—*Catatropis filamentis* Barker, ventral view.

PLATE 2

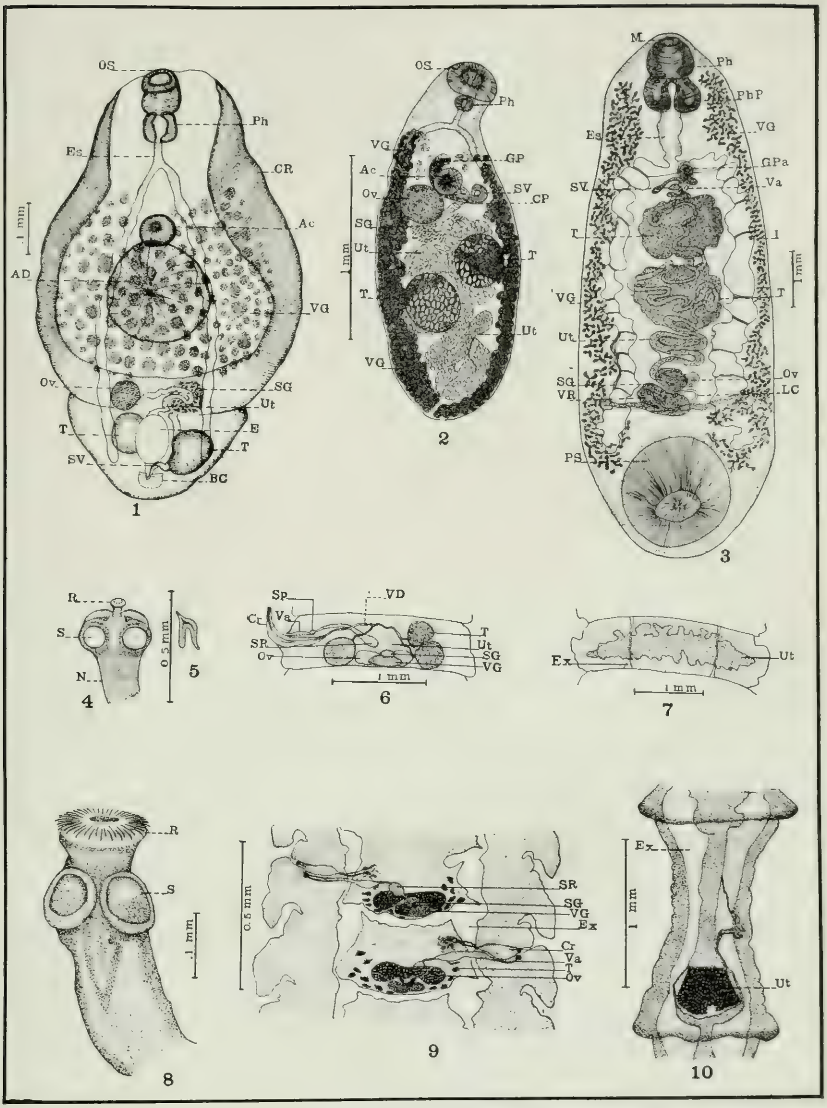

Fig. 1.—*Hemistomum craterum* Barker and Noll, ventral view.

Fig. 2.—*Plagiorchis proximus* Barker, ventral view.

Fig. 3.—*Wardius zibethicus* Barker and East, ventral view, specimen compressed.

Fig. 4.—Scolex of *Hymenolepis evaginata* Barker and Andrews.

Fig. 5.—Hook of *Hymenolepis evaginata.*

Fig. 6.—Mature proglottid of *Hymenolepis evaginata.*

Fig. 7.—Gravid proglottid of *Hymenolepis evaginata.*

Fig. 8.—Scolex of *Anomotaenia telescopica* Barker and Andrews.

Fig. 9.—Mature proglottid of *Anomotaenia telescopica,* reconstruction from frontal sections.

Fig. 10.—Gravid proglottid of *Anomotaenia telescopica.*

of shell gland. Uterus median with densely coiled transverse tubes extending from anterior testis to genital pore.

Eggs numerous, oval, light brownish color, 0.104 to 0.108 mm. by 0.067 to 0.070 mm. Lids small, opercular rim absent. Excretory reservoir tubular, in median plane of posterior part of body, forming a large bulb-like reservoir at extremity of body; excretory pore terminal, median.

Found in duodenum of host.

Echinoparyphium contiguum Barker and Bastron, *sp. nov.*[4] (Plate 1, Fig. 3).

Body spindle- or boat-shaped, flattened dorso-ventrally, anterior end tapering, posterior end bluntly rounded. Length 3.3 to 4.3 mm.; width 0.57 to 0.70 mm. at level of acetabulum. Oral sucker almost surrounded by well-defined collar with ventral median incision. Collar has 37 spines arranged in alternate rows of 14 oral and 15 aboral spines on rim and one set of 4 on each ventral flap or lappet. Cuticula smooth, without spines. Oral sucker subterminal, 0.12 to 0.16 mm. by 0.09 to 0.14 mm.

Large circular muscular acetabulum, 0.45 to 0.57 mm. in diameter at middle of anterior half of body. Oval muscular pharynx separated from mouth by short prepharyngeal tube. Wide, thin-walled esophagus extending from pharynx to level of acetabulum where it bifurcates; intestinal ceca extend straight to posterior end of body and end blindly.

Ovary small, ovoid, 0.16 to 0.19 mm. by 0.14 to 0.15 mm. in middle of body, slightly to left of median line. Shell gland diffuse, without definite outline, at level of ovary and to right of median line. Laurer's canal present. Seminal receptacle not evident. Testes very large, in anterior part of posterior half of body, median, one directly behind the other. Uterine coils loose, occupying intercecal zone between shell gland and acetabulum. Vagina opens with cirrus at genital pore just posterior to bifurcation of esophagus. Cirrus pouch club-shaped, extending from genital pore obliquely caudad, dextral and dorsal to acetabulum. Its base at level of middle of acetabulum. Large tubular seminal vesicle, granular prostate gland, and muscular cirrus lie within cirrus pouch.

Vitelline glands coarsely acinous, extending in continuous lateral masses from acetabulum to extreme posterior end of body. Masses more voluminous caudad to posterior testis. Transverse vitelline ducts and median vitelline reservoir at level of anterior margin of anterior testis. Eggs limited in number, from 30 to 100; oval, 0.096 to 0.109 mm. in length by 0.068 to 0.070 mm. in width. Lid present.

4. Extract of unpublished research by Franklin D. Barker and Carl Bastron.

Excretory system Y-shaped, lateral arms unite just caudad to posterior testis, forming large tubular median reservoir; excretory pore median and slightly ventral, at posterior end of body.

Found in duodenum of host.

Echinostomum callawayensis Barker and Noll, *sp. nov.*[5] (Plate 1, Fig. 1).

Body spatulate; anterior end tapering, posterior end bluntly rounded. Length 4.28 to 6.91 mm.; width 1.04 to 1.49 mm. Anterior end almost entirely surrounded by oval collar-like expansion, 0.34 to 0.51 mm. wide, having a definite ventral incision. Collar armed with double row of alternately arranged spines varying in number from 37 to 41, 31 to 33 on rim and 2 to 5 on each flap. Length of collar spines 0.0385 to 0.056 mm., mid-dorsal spine being smallest. Cuticula smooth, without spines. Acetabulum circular, cavity sac-like, musculature well developed, lying between first and second anterior fourths of body.

Oral sucker 0.08 to 0.16 mm. long by 0.12 to 0.17 mm. wide, separated from pharynx by short narrow prepharyngeal tube. Weakly developed but wide esophagus bifurcates into narrow ceca which broaden posterior to acetabulum and end blindly between posterior testis and posterior end of worm. Testes more or less elliptical, lying tandem in anterior three-fourths of posterior half of body. Cirrus pouch, pear-shaped, containing thick, muscular-walled cirrus, tubular somewhat coiled seminal vesicle, and granular prostate gland; pouch right or left and anterior to middle of acetabulum. Genital pore right or left of median line and anterior to acetabulum.

Ovary nearly globular, in middle of body right or left of median line; large, compact, well-defined, pear-shaped shell gland between ovary and anterior testis. Uterine coils compact, almost entirely anterior to ovary, filling region between intestinal ceca. Laurer's canal present; seminal receptacle not found. Eggs numerous, straw colored, oval, lid small, without opercular rim; length 0.0805 to 0.1015 mm., width 0.042 to 0.063 mm. Vitelline glands coarsely acinous, extending from posterior border of acetabulum in continuous lateral masses to posterior end of worm; posterior to testis vitelline glands extend toward median line but do not coalesce. Transverse vitelline duct and reservoir at level of anterior margin of anterior testis.

Excretory system Y-shaped, with slender median reservoir; excretory pore in median line at posterior end of worm.

Found in duodenum of host.

5. Extract of unpublished research by Franklin D. Barker and William C. Noll.

Echinostomum armigerum Barker and Irvine, *sp. nov.*[6] (Text Fig. *A*).

Body elliptical, somewhat flattened dorsoventrally, anterior end slightly tapering, posterior end wider and more rounding. Length 9.4 to 12.4 mm.; width 1.2 to 1.8 mm. When alive pinkish gray color. Oral sucker almost completely surrounded by well-developed collar bearing 37 chitinous spines arranged in three sets, 27 around rim and 5 on each ventral point of collar. Collar spines vary in length from 0.061 to 0.094 mm., those on points of collar being smallest. Well marked median ventral break in collar. Anterior third of body covered by small spines 0.030 mm. long. Acetabulum prominent, pouch-like at juncture of anterior and middle thirds of body.

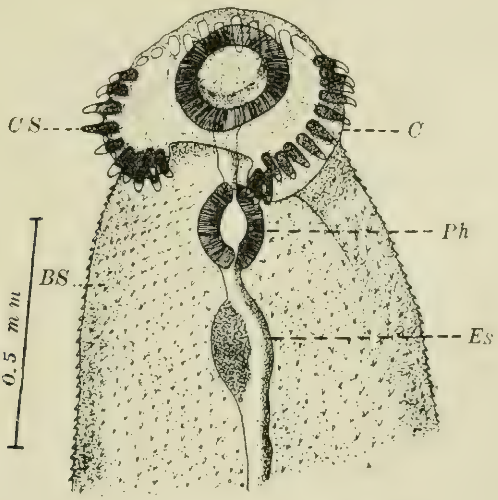

Fig. A.—Anterior end of *Echinostomum armigerum: Bs,* body spinelets; *C,* collar; *Cs,* collar spines; *Es,* esophagus; *Ph,* pharynx.

Digestive tract well developed; intestinal ceca somewhat undulating and rather narrow, ending blindly in extreme posterior end of worm. Testes quadrate to triangular, irregularly lobed, lying tandem and close together between middle and posterior thirds of body. Cirrus pouch pear shaped, surrounding large thick walled cirrus, and tubular somewhat coiled seminal vesicle, at level of anterior margin of acetabulum. Genital pore median between anterior margin of acetabulum and transverse arms of ceca.

Ovary pear-shaped, anterior to testes, median, transverse. Well-defined shell gland, slightly larger than the ovary, between anterior

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6. Extract of unpublished research by Franklin D. Barker and Robert S. Irvine.

testis and ovary, slightly to one side. Laurer's canal and seminal receptacle not found. Uterine coils fairly compact, in transverse coils for most part anterior to ovary in median field. Eggs numerous, straw-colored, ovoid, operculum small and without opercular rim; size 0.084 to 0.105 mm. by 0.057 to 0.066 mm.

Vitelline glands coarsely acinous, extending in continuous masses, from acetabulum, in lateral fields, to posterior end of worm. Transverse vitelline ducts and reservoir at level of shell gland. Excretory system two lateral vessels which unite in region of posterior third of body and form slender median excretory reservoir; excretory pore in median line at posterior end of worm.

Found in duodenum of host.

Notocotyle quinqueseriale Barker and Laughlin, (Plate 1, Fig. 5).

Characters in general like those of genus. Ventral surface provided with five distinct longitudinal rows of wart-like papillae extending from anterior to posterior end, with 16 to 18 papillae in each row. Cuticula without spines. Length of body, 2.5 to 4.0 mm.; width 0.66 to 1.33 mm. Cirrus pouch elongated, extending from posterior margin of oral sucker to middle third of body. Vagina as long as cirrus pouch. Eggs light straw color, oval, with long polar filament at each end; 0.019 to 0.021 mm. long, 0.01 to 0.013 mm wide. Polar lid present. Most abundant parasite found; generally occurs in cecum.

Catatropis fimbriata Barker, *sp. nov.*[7] (Plate 1, Fig. 6).

Body thin, flat, gradually tapering anteriorly. Length 2.2 to 3.3 mm., width at level of testes 0.56 to 0.70 mm. Anterior half of body covered with minute needle-like spines in definite oblique rows. Three longitudinal rows of flattened circular papillae on ventral surface; 12 to 13 papillae in each row. Oral sucker, sub-terminal, oval 0.079 to 0.099 mm. wide, 0.066 to 0.092 mm. long. Pharynx absent; esophagus 0.105 to 0.132 mm. long; intestinal ceca undulating, external to uterine coils, internal to testes, end blindly in posterior end of worm. Testes opposite, at same level in posterior fifth or sixth of body, weakly two- to four-lobed; 0.198 to 0.257 mm. long, 0.132 to 0.151 mm. wide; vas deferens prominent, median, extends from shell gland to base of cirrus pouch; cirrus pouch tubular, greatly elongated, extends from level of intestinal bifurcation caudad to level of middle third of body. Seminal vesicle coiled at base of and almost entirely outside of cirrus pouch. Prostate gland and muscular cirrus covered with papillae within pouch. Ovary between testes, globular or oval, margin undulating 0.132 mm. long by 0.105 to 0.112 mm. wide. Uterine coils transverse, numerous compact, in intercecal zone. Vagina straight, walls

7. Abstract of unpublished research by Franklin D. Barker.

quite muscular, as long as cirrus pouch. Genital pore ventral, median, just caudad to intestinal bifurcation. Shell gland, compact, definite, ovoid, immediately anterior to and a little larger than ovary.

Vitelline glands, lateral in extracecal zone in posterior half of body, extending from middle of body caudad to level of testes, 12 to 15 rather definite, irregular acini on each side. Excretory canal tubular, undulating, extends in median line from ovary to posterior end of body. Eggs elongated, oval, 0.020 to 0.022 mm. long, 0.011 mm. wide; shell thick, with lid and long polar filament at each end, 0.084 to 0.098 mm. long.

Found in duodenum of host.

Hemistomum craterum Barker and Noll, *sp. nov.*[8] (Plate II, Fig. 1).

Body divided into cephalic and caudal regions; cephalic region thin, flat, wide, anterior portion tapering, lateral margins turn ventrad and mesad one fifth width of region; caudal region thick, rounding, conical. Length of entire worm 0.75 to 1.89 mm. Length of cephalic region 0.62 to 0.79 mm., width 0.41 to 0.49 mm.; length of caudal region 0.28 to 0.47 mm., width 0.20 to 0.36 mm.

Body spines not evident. Oral sucker muscular subterminal, nearly circular, 0.075 to 0.094 mm. in diameter. Acetabulum at posterior margin of anterior half of cephalic region, circular, 0.075 mm. in diameter. Adhesive disk large, flattened cone with crater-like top, muscular without papillae; median in anterior portion of posterior half of cephalic region. Frequently overlaps acetabulum. Size 0.19 to 0.22 mm. in diameter.

Pharynx oval, 0.07 mm. long by 0.073 mm. wide. Esophagus narrow, straight, 0.06 mm. long. Intestinal ceca narrow, tubular, undulating, terminating blindly in posterior end of caudal region. Ovary at junction of body regions to right of median line. Globular, margins smooth 0.07 mm. in diameter. Shell gland diffuse, in same plane but on opposite side from ovary.

Uterus, winding turns to left then caudad to bursa copulatrix, which is dorsal and subterminal in posterior end of worm. Vitelline glands voluminous globular acini, filling posterior two thirds of cephalic region. Testes two, globular or oval, entire or slightly lobed at about middle level of caudal region on either side of median line, slightly oblique. Twice as large as ovary. Seminal vesicle, large, winding tube slightly to left of median line between testes; opens into bursa. Genital pore slit-like, dorsal, median, subterminal, at posterior end of worm. Eggs, large, oval, few, one to three; thin shell, small operculum, size 0.11 by 0.07 mm.

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Found in duodenum and cecum of host; only in one out of forty-six muskrats examined.

Plagiorchis proximus Barker, *sp. nov.*[9] (Plate II, Fig. 2).

Body plump, oval, tapering anteriorly, bluntly rounding posteriorly. Color creamy, opaque. Minute spinelets cover anterior two thirds of body. Length 1.32 to 1.98 mm., width at level of anterior testis 0.49 to 0.66 mm. Oral sucker muscular, terminal, 0.085 to 0.125 mm. long by 0.105 to 0.115 mm. wide. Pharynx immediately posterior to oral sucker, 0.035 to 0.05 mm. long by 0.045 to 0.055 mm. wide. Esophagus as long as pharynx. Intestinal ceca, simple, straight, extend almost to posterior end of body. Acetabulum, between first and second fourths of body; muscular, circular, 0.065 to 0.11 mm. long by 0.075 to 0.105 mm. wide. Ovary, globular to oval, margins smooth, immediately posterior to acetabulum and to right of median line. Margin separated by width of cirrus pouch, or touches posterior margin of acetabulum. Size 0.095 to 0.145 mm. long by 0.10 to 0.11 mm. wide. Uterine coils winding, descending limb passes caudad from ovary between testes filling posterior end of body, ascending limb passes between testes cephalad to genital pore; coils overlap testes but do not overlap intestinal ceca. Eggs very numerous. Vitelline glands voluminous, coarse globular acini lateral and partly dorsal and ventral, extend uninterrupted from slightly anterior to acetabulum to extreme posterior end where they tend to fuse; glands overlap and obscure intestinal ceca; shell gland, diffuse, posterior and to left of ovary. Seminal receptacle and Laurer's canal not evident. Testes, globular, margins smooth, in anterior portion of posterior half of body, one obliquely behind the other, slightly separated. Testes measure 0.125 to 0.160 mm. long by 0.120 to 0.150 mm. wide. Cirrus pouch, narrow, elongated, tubular; base just posterior to acetabulum and to left of median line; pouch turns transversely to right then cephalad dorsal and to right of acetabulum to the genital pore. Genital pore in median plane just anterior to acetabulum. Eggs numerous, straw color, operculum, with rim present, opercular end broad, opposite end tapering. Size 0.032 to 0.0378 mm. long by 0.020 to 0.024 mm. wide.

Found in duodenum of host.

Wardius zibethicus Barker and East, *Gen. et sp. nov.*[10] (Plate II, Fig. 3).

Large thick worms, 4 to 13 mm. long by 1 to 4.5 mm. wide; body broadly oblanceolate; anterior end tapering and bluntly conical, posterior end broader and rounded. Cuticula smooth without spines or

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9. Abstract of unpublished research by Franklin D. Barker.

10. Abstract from unpublished research by Franklin D. Barker and Anna M. East.

wart-like projections. Oral sucker absent; large muscular, cup-shaped sucker, posterior, ventral and subterminal; antero-posterior diameter 1.116 to 2.79 mm., transverse diameter 1.116 to 2.294 mm.; opening of sucker 0.3 to 1.55 mm. in diameter. Small, terminal mouth leads directly into muscular, elongated, cup-shaped pharynx (or oral sucker), size 0.434 to 0.992 mm. by 0.434 to 0.992 mm. pharynx with two dorsal, postero-lateral pockets often as large as pharynx; 0.45 to 1.08 mm. in length by 0.45 to 0.99 mm. in breadth. Pharynx leads into well-developed simple esophagus, without muscular thickenings; 0.62 to 2.17 mm. long and 0.186 to 0.30 mm. wide, bifurcating at level of first and second fourths of body; intestinal ceca sinuous, with numerous short lateral pockets, terminating blindly at level of anterior margin of posterior sucker.

Two testes weakly, but not regularly lobed, close together in tandem position in middle third of body. Testes vary from orbicular to transversely elliptical, 0.496 to 1.736 mm. in length by 0.496 to 2.294 mm. in width.

Male genital tract terminates in much convoluted and distended vesicula seminalis followed by slightly convoluted pars musculosa and pars prostatica surrounded by prostate gland. Short ductus ejaculatorius opens at base of genital papilla, ventral, right or left of median plane just posterior to intestinal bifurcation and slightly anterior to anterior margin of anterior testis; hermaphroditic duct and genital sucker absent. Ovary median, at level of posterior third of body, orbicular or transversely oval with smooth or undulating margin. Shell gland somewhat diffuse, right or left of, and posterior to ovary. Laurer's canal right or left and posterior to ovary; opening dorsal, median, slightly anterior to posterior sucker. Vitelline glands small globular acini, continuous, extending from level of pharynx to middle of posterior sucker, almost entirely outside of intestinal ceca. Two transverse vitelline ducts and prominent yolk reservoir at level of shell gland. Uterus in median plane, anterior to the ovary. Coils transverse, loose to compact. Metraterm opens at base of genital papilla through common genital pore.

Eggs, elongated, oval, numerous; opercular end tapering, 0.016 to 0.019 mm. by 0.009 to 0.014 mm. Operculum small, opercular rim absent. Excretory system complex consisting of two longitudinal canals, mesal of intestinal ceca, with numerous anastomizing laterals, extending from anterior end to posterior sucker where they empty into large vesicular reservoir dorsal and in part posterior to anterior margin of posterior sucker. Excretory pore dorsal, median at level of anterior margin of posterior sucker.

Generally found in cecum of host.

CESTODES

Hymenolepis evaginata Barker and Andrews, *sp. nov.*[11] (Plate II, Figs. 4, 5, 6, 7).

Worms 20 to 40 cm. long, 300 to 900 proglottids. In living worm posterior three centimeters greatly contracted, thick, rigid, opaque, anterior portion of body abruptly becomes thin, flabby, transparent. Proglottids four to eight times wider than long. Gravid posterior proglottids 2 to 3 mm. by 0.36 mm., anterior proglottids 0.15 to 0.30 mm. by 0.045 mm. Lateral edges project slightly. Genital pores unilateral in middle of proglottid. Scolex well developed, inverted pear-shaped, 0.33 mm. wide; four muscular circular suckers present, 0.09 to 0.11 mm. in diameter. Rostellum elongated, retractile, pestle-shaped, armed with single row of ten comparatively large hammer-shaped hooks, 0.007 mm. long by 0.004 mm. wide. Three testes, large, globular; one on one side and two, one obliquely anterior to other, on opposite side. Cirrus elongated, muscular, posterior to vagina. Ovary transversely elongated, bilobed, median, posterior; vitelline gland, transversely elongated, median, behind ovary. Shell gland oval, median, anterior to vitelline gland. Mesal end of vagina swollen to form seminal receptacle anterior to ovary. Vagina opens anterior to cirrus. Gravid uterus transversely elongated, sac-like, anterior and posterior margins lobulated, partitions absent. Eggs oval, thin shell, 0.0206 by 0.0162 mm.

Found in duodenum of host.

Anomotaenia telescopica Barker and Andrews, *sp. nov.*[12] (Plate II, Figs. 8, 9, 10).

Preserved specimens 115 to 130 mm. long, with 600 to 700 proglottids. Body heavy, rugged, opaque, proglottids markedly telescoped, edges serrated, mature proglottids four to five times wider than long, gravid proglottids three to four times longer than wide. Mature proglottids 1.1 mm. wide; 0.5 mm. long, 0.17 mm. thick. Gravid proglottids 1.5 mm. long by 0.5 mm. wide. Genital pores irregularly alternate. Scolex well developed 0.17 mm. wide with four muscular, circular, cup-shaped suckers. Rostellum strongly developed, wide, armed with double row of forty-eight alternately arranged, elongated hooks. Inner row of twenty-four hooks, 0.057 mm. long; outer row of twenty-four hooks 0.047 mm. long.

Testes limited in number, in lateral and posterior regions of mature proglottids. Cirrus pouch short, muscular, anterior to vagina. Ovary transversely elongated, weakly bilobed, median, posterior. Vitelline gland compact elongated, median, posterior to ovary. Shell gland

11. Abstract of unpublished research by Franklin D. Barker and Mitchell Andrews.

12. Abstract of unpublished research by Franklin D. Barker and Mitchell Andrews.

oval, median, anterior to vitelline gland. Seminal receptacle prominent, sac-like, anterior to ovary. Vagina elongated, muscular. Uterus, sac- or pouch-like in posterior portion of gravid proglottids, without median stem or lateral branches. Eggs spherical, 0.013 mm. in diameter, shell thick.

Found in duodenum of host.

NEMATODA

Trichuris opaca Barker and Noyes, *sp. nov.*[13] (Text Fig. *B*).

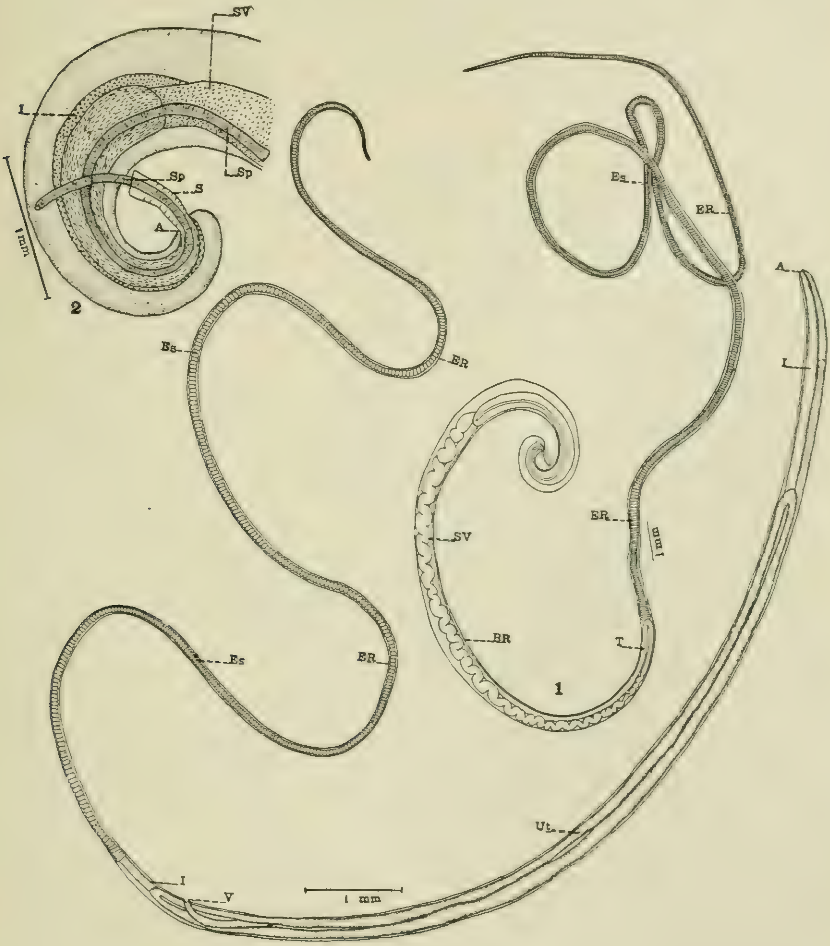

Fig. B, 1.—*Trichuris opaca,* male. Fig. 2.—*Trichuris opaca,* posterior end of male. Fig. 3.—*Trichuris opaca,* female. *A,* anus; *B R,* body region; *E R,* esophageal region; *Es,* esophagus; *I,* intestine; *S,* Spicule sheath; *Sp,* spicule; *S V,* seminal vesicle; *T,* testis; *Ut,* uterus; *V,* vulva.

13. Abstract from unpublished research by Franklin D. Barker and Bessie Noyes.

Body cylindrical, stiff, opaque, divided into long slender esophageal region and shorter, thicker body region. Anterior portion attenuated, tapering, rounded; posterior blunt, rounded; anus a little subterminal.

Male: 22 to 28 mm. long; esophageal region 13 to 19 mm. long, 0.06 to 0.08 mm. wide; body region 7 to 9 mm. long, 0.14 to 0.16 mm. wide. Posterior end rolled into spiral. Spicule 2 mm. long by 0.017 mm. broad surrounded by sheath covered by minute blunt spinelets; sheath when evaginated 0.18 mm. long by 0.07 mm. broad.

Female: 28 to 30 mm. long; esophageal region 18 to 19 mm. long, 0.06 to 0.07 mm. wide; body region 10 to 11.1 mm. long, 0.23 to 0.25 mm. wide. Posterior portion slightly curved. Vulva between first and second anterior elevenths of body region. Anus nearly terminal.

Found in duodenum of host.

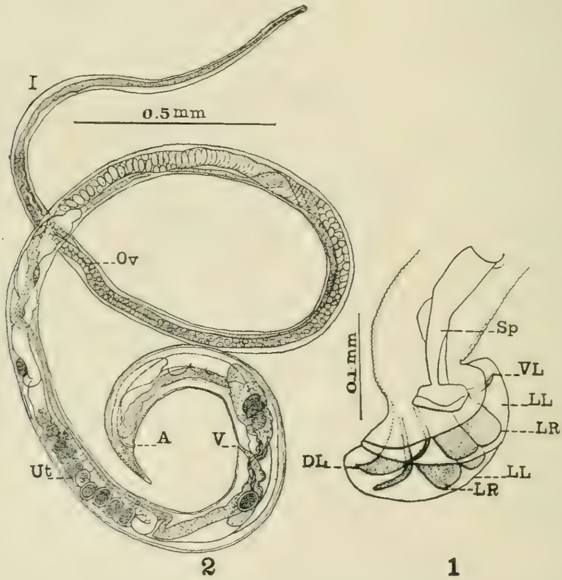

Fig. C, 1.—*Trichostronguius fiberius*, posterior end of male. Fig. 2.—*Trichostrongylus fiberius*, female. *A*, anus; *D L*, dorsal lobe; *D L R*, dorso-lateral lobe; *I*, intestine; *L L*, lateral lobe; *L R*, lateral ray; *Ov*, ovary; *Sp*, spicule; *Ut*, uterus; *V*, vulva; *V L*, ventro-lateral ray.

Trichostrongylus fiberius Barker and Noyes, *sp. nov.*[14] (Text Fig. *C*).

Body thread-like, anterior region greatly attenuated, body gradually widens toward posterior end. Buccal cavity and teeth absent.

Male: 2.8 mm. long; width just posterior to mouth 0.013 mm., anterior to bursa 0.09 mm. Bursa with two wide lateral lobes and

14. Abstract from unpublished research by Franklin D. Barker and Bessie Noyes.

narrow dorsal median lobe. Lateral lobes with two wide, blunt, lateral rays and one narrow, pointed dorso-lateral and one ventro-lateral ray. Spicules short and heavy.

Female: 4.7 mm. long; width posterior to mouth 0.03 mm., at level of vulva, 0.135 mm. Vulva in posterior ninth of body 0.52 mm. from end. Anus 0.08 mm. from posterior end. Posterior end slightly curved and pointed. Eggs oval, segmented, 0.059 by 0.036 mm., shell, thick.

Found in duodenum and cecum of host.

Capillaria ransomia Barker and Noyes, *sp. nov.*[15] (Text Fig. *D*).

Body capillary, not divided externally into two regions, gradually increasing in width in body region. Anal opening subterminal.

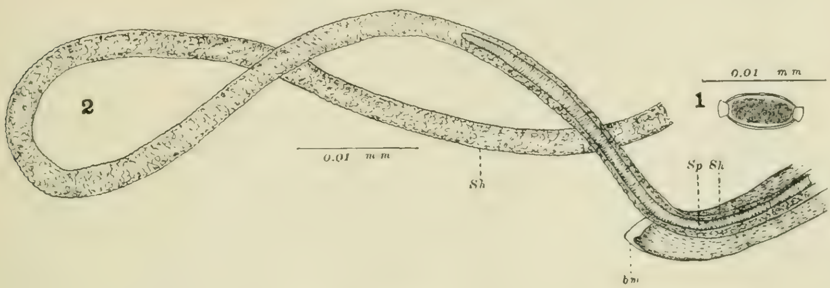

Fig. D, 1.—Egg of *Capillaria ransomia.* Fig. 2.—Caudal region of male, *Capillaria ransomia,* lateral view; *bm,* bursal membrane; *sh,* spicule sheath; *sp,* spicule.

Male: 19.6 mm. long, width posterior to mouth 0.01 mm., in posterior region 0.032 mm. Posterior end slightly curved; small bursa present with two lateral lobes; one spicule, 1.36 mm. long by 0.007 mm. wide; spicule sheath 0.01 mm. wide.

Female: 19 mm. long; width posterior to mouth 0.022 mm., posterior region 0.065 mm. Vulva in anterior fourth of body, 5 mm. from anterior end. Eggs with prominent plugs, 0.05 mm. by 0.02 mm.

Found in duodenum of host.

It is hoped that these preliminary descriptions will stimulate and facilitate further investigations of the parasites of the muskrat in other localities.

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15. Abstract from unpublished research by Franklin D. Barker and Bessie Noyes.

GORDIUS LARVAE PARASITIC IN A TREMATODE *

William Walter Cort
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During the summer of 1914 while carrying on investigations at the University of Michigan Biological Station, Douglas Lake, Michigan, I collected some trematodes which contained in their parenchyma early developmental stages of Gordius larvae. This observation seems worth reporting, especially since no record has been found of a trematode parasitized by another animal.

These trematodes, which belong to the species *Brachycoelium hospitale* Stafford, were found in the intestines of specimens of the green newt (*Diemictylus viridescens*) from a small beach pool on the north side of Douglas Lake. The anatomy of this fluke has been described by Stafford (1903 : 824). The infection of the Douglas Lake newts while not particularly heavy is considerably greater than that reported by him. Of nineteen individuals of *Diemictylus viridescens* examined, thirteen were infected with a total of thirty-seven specimens of *Brachycoelium hospitale,* the greatest number in one host being eight.

The accidental finding of a Gordius larva coiled up in the parenchymatous tissue of one of the trematodes led to further examination. In all, sixteen of the trematodes were examined carefully for the presence of these larvae. Eight of them from several different hosts were infected, two containing two larvae and the others one each. The Gordius larvae were found in various positions: one was next to the oral sucker, another just anterior to the ovary, and others near the testes or further posteriad among the uterine coils (Fig. 1).

The Gordius larvae in the trematodes were in a very early stage of development, being but little beyond the condition found in fully developed eggs. They floated freely in spaces in the parenchymatous tissue. No spontaneous movement was noted and there was no indication of a cyst. The larvae were coiled very tightly; the anterior end appeared truncated, and the proboscis entirely retracted. The posterior extremity was terminated by a short spine (Fig. 2). There was no indication that the larvae were continuing their development in the tissues of the trematode.

Early larval stages of the Gordiacea have been found in a large variety of aquatic animals. Villot (1891 : 338) states that the "embryo" of *Gordius aquaticus* has been found in the mesenteries of *Rana tem-*

* Publication No. 31 from the University of Michigan Biological Station.

poraria, in aquatic insect larvae (*Tanypus, Corethra, Chironomus*), in the parenchyma of leeches, in the mucous membrane of the intestine of fishes, and even in the foot of snails. Which of these are normal hosts is a matter of dispute, some authorities favoring the insect larvae and some the fishes. The presence of Gordius larvae in trematodes from the intestine of the newt is without doubt a case of accidental parasitism, the larvae ingested by the newt having sought to escape the

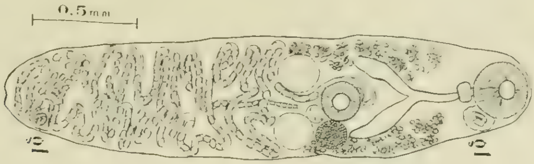

Fig. 1.—A specimen of *Brachycoelium hospitale* containing two Gordius larvae (*gl*). X 28.

intestinal juices by boring into the trematodes. That the trematode can have any normal place in the life-history of Gordius is evidently unlikely since the adult trematode finishes its life in the intestine of its host and under these conditions the encysted larvae can hardly reach a place suited for further development. Probably after hatching from the egg Gordius larvae by the use of their extraordinary boring apparatus are able to make their way into almost any aquatic animal.

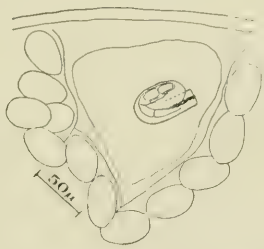

Fig. 2.—Gordius larva in parenchyma of posterior end of fluke shown in Figure 1. X 160.

Many of them wander into places where development stops; but the continuation of the species depends on a few of the myriads hatched finding some normal host, i. e., one in which complete development is possible. The life history thus appears to be only roughly adjusted and to lack the precise relations shown by many other parasitic species.

LITERATURE CITED

Stafford, J. 1903. Two Distomes from Canadian Urodela. Centralbl. Bakteriol. u. Parasit., (1) Orig., 34: 822-830.

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SOCIETY PROCEEDINGS

THE HELMINTHOLOGICAL SOCIETY OF WASHINGTON

The twenty-fifth regular meeting of the Society was held at the residence of Dr. Stiles on March 26, 1915, Dr. Stiles acting as host and Dr. Ransom as chairman.

Dr. Cobb presented some figures of a species of *Bunonema,* pointing out the fact that the large cuticular bosses, which had been described by other workers as dorsal or ventral, were really located on the right side of the worm in this genus, the animal in consequence being notably asymmetrical.

Dr. Cobb also gave a demonstration of the workings of the new Bausch & Lomb projection apparatus, using the nitrogen-filled, tungsten-filament bulb.

Dr. Stiles gave a résumé of the sanitary campaign in some parts of the southern United States, and pointed out the considerable advantage to be gained by methods of civic education as opposed to the use of military and police methods. Educational methods work from the inside, and secure cooperation without arousing hostility. In actual practice, the greatest reforms accomplished anywhere in the South were accomplished without the arrest of a single individual or the imposition of one fine. A striking economic feature of the work in Wilmington, North Carolina, was the appropriation of $50,000 by the city to be used as a loan fund for the installation of sewer service. Any person financially unable to install sewer service could borrow the necessary money from the city, the city taking a lien on the property for the loan, and could pay the money back in easy instalments, the city charging 6 per cent. interest on the loan.

Dr. Hall presented a paper entitled "A Case of *Taenia saginata* Presenting Structural Abnormalities and Associated with Spurious Parasitism in an Infant."

Dr. Ransom exhibited some specimens of trichinae digested out of meat exposed three weeks to temperatures of 15, 10 and 5 F., respectively, and for comparison some specimens digested out of unfrozen meat. The normal trichinae examined at room temperature were seen to be tightly coiled; the esophageal cell body was brown in color; its nuclei clear and vesicular, and the reproductive cells formed a continuous hyaline mass. Those from meat exposed to 15 F. were less tightly coiled; the color of the cell body was less pronounced; the granulation of the protoplasm of the esophageal cells differed somewhat from normal, and in some cases there was a tendency toward dissociation of the reproductive cells. Those from meat exposed to 10 F. were loosely coiled, and in many cases had assumed the form of a figure 6; the color of the cell body was much paler than normal; the nuclei of the esophageal cells were more or less solidified; the protoplasm of these cells was abnormally granular, and the reproductive cells were more or less dissociated, tending toward a spherical form. The larvae from meat exposed to 5 F. had assumed the form of a figure 6; the esophageal cell body had entirely lost its brown color; the nuclei were solidified or not apparent; the protoplasm showed a pronounced abnormal granulation, and the reproductive cells were either dissociated or broken down into a granular mass. The exact nature of the changes produced by low temperatures is not known, but it is evident that the changes become more marked as the temperature becomes lower. Possibly there is a separation of colloids which are unable after thawing to resume their former relations in the protoplasmic complex. The viability of the larvae is materially affected by exposure to low temperatures. Infections may result after exposure to temperatures of 10 F. and 15 F., but none has resulted in numerous trials from the feeding of meat exposed for

three weeks to temperatures of 5 F. and lower. Examined on a warm stage most of those exposed to 15 F. are active motile; a smaller proportion of those exposed to 10 F. are active, whereas none of those exposed to 5 F. or lower have exhibited other than very feeble movements, and only very rarely have they shown even the faintest signs of life.

MAURICE C. HALL, *Secretary.*

The twenty-sixth regular meeting of the Society was held at the residence of Dr. Ransom on April 22, 1915, Dr. Ransom acting as host and Mr. Crawley as chairman.

Dr. Stiles presented a paper on the parasites of schoolchilren in a Southern city. The data were tabulated with regard to race, sex and the presence of sewer connections or privy in the home of the pupil. Of 2,448 white children, fecal samples were obtained from 776; and of 1,346 negro children, fecal samples were obtained from 511. Of the total number of children, 2,448 white and 1,346 negro, 20 per cent. of the white children and 76 per cent. of the negro children were from homes with privies. A higher percentage of samples was obtained from negro children (38 per cent.) than from white children (32 per cent.), showing that it is possible to obtain the cooperation of the negroes to a notable extent, if the cooperation is sought in the right manner. The poorer showing of the white children is to be explained in part by the natural diffidence displayed by white girls, samples being obtained from only 26 per cent. of these.

Of 776 white pupils, 36.73 per cent. had intestinal parasites, and of 511 negroes, 49.12 per cent. had intestinal parasites. It is evident, then, that the negroes, coming from homes usually provided with privies (76 per cent.) and seldom with sewer connections, have a higher infestation than white children coming from homes usually provided with sewer connections and seldom provided with privies (20 per cent.). However, the percentage of infestation among negro boys and girls was practically identical, indicating a similar degree of cleanliness or lack of it for both sexes, whereas the percentage of infestation among white boys was higher than among white girls, indicating a greater degree of cleanliness among the white girls as compared with white boys. The white boys from homes provided with sewers showed a greater degree of infestation than white girls from homes having only privies. It may be surmised that this follows not only from the greater cleanliness of the white girls, but a more roving disposition on the part of the white boy. The white boys from home having privies showed a greater infestation than negro boys and girls from similar homes, but in connection with these figures it should be noted that the number of white boys in this category is very small and the resultant percentage less apt to be reliable or representative.

Parasites were considered in two groups: 1. Those that could only be acquired as the result of ingesting human feces in some way, and including Entameba, Lamblia, Trichomonas, Oxyuris, Ascaris and Trichuris. 2. Those that might be acquired in some other way, including Hymenolepis and Necator.

Of the 776 white children, 28 per cent., and of 511 negro children, 48 per cent., were infested with parasites of the first group, the infestation for each parasite being as follows: *Entameba coli,* 8.7 per cent. of whites and 11.9 per cent. of negroes; Lamblia, 12.7 per cent. of whites and 6.5 per cent. of negroes; Trichomonas, only 5 infestations, all in whites, 0.6 per cent.; *Ascaris lumbricoides,* 7.5 per cent. of whites and 27.9 per cent. of negroes; *Oxyurias vermicularis,* only 3 infestations, all in whites, 0.4 per cent.; *Trichuris trichiura,* 1.3 of whites and 11.5 per cent. of negroes.

Of the same children, 10.9 per cent. of the white children and 3.5 per cent. of the negroes were infested with parasites of the second group, the infestation for each parasite being as follows: *Hymenolepis nana,* only 3 cases, 0.3 per cent. of whites and 0.2 per cent. of negroes; *Necator americanus,* 10.7 per cent. of whites and 3.3 per cent. of negroes. The question may be raised as to whether the thicker skin and the odor of the feet may serve as a protection in the case

of the negro, or whether there is a partial resistance developed in the native home of the parasite and of the negro in Africa.

Dr. Ransom presented a note reporting a case of *Paragonimus westermanii* or *P. kellicotti* in a cat. The diagnosis is based upon eggs found in the bronchial mucus and muscles by Dr. W. H. Schultz of Morgantown, West Virginia, specimens of which were sent to the Bureau of Animal Industry for identification. Cases of *Paragonimus* are occasionally found in hogs killed at certain meat inspection stations, particularly at Cincinnati, Ohio, but none of these cases has been traced to the point of origin. Hence the present case is of special interest, as it indicates a probable center of infection, in the neighborhood of which other cases may be expected to occur.

Mr. Crawley presented a note on the geometrical ratio of multiplication in the increase of protozoa in infestation, with an apparent exception in the case of sarcosporidia.

The presence of *Sarcocystis muris* in a mouse from which the skin has been removed, is readily detected. The cysts, owing to the presence of refractive granules, look like white threads running lengthwise in the muscles. When scarce, however, they may be confused with the connective tissue fibers or even overlooked altogether, and such cases can only be positively diagnosed by the use of the microscope.

In the case of thirteen mice, which either died or were killed at known periods after inoculation, five were macroscopically negative, but the microscope showed them to be positive. The periods elapsing between inoculation and death were, respectively, 75, 75, 83, 211 and 273 days.

The remaining eight mice were all macroscopically positive, and the character of the infections was classified as slight, moderate and severe, the latter being those cases wherein the flesh of the mouse is so overloaded with cysts that, considered as a whole, it is white and not red. The slight infections numbered two, with periods of 100 and 205 days. The moderate infections numbered four, with periods of 158, 175, 225 and 233 days. The two severe infections had periods of 216 and 233 days.

The indications from these data are that the time during which the infection has lasted and the intensity it finally assumes bear no relation to each other. Thus, two of the cases which required the microscope for their demonstration had periods of 211 and 273 days, whereas the periods for the two severe cases were only 216 and 233 days.

Hence the inference is that the number of cysts which finally appear in the muscles is directly related to the number of spores originally ingested. If so, this would constitute a noteworthy exception to the general rule for infections of parasitic protozoa to the effect that the severity an infection ultimately attains bears no relation to the number of individuals originally inoculated. This, of course, is due to the fact that, in general, the parasites increase in geometrical ratio, and continue to do so until the host succumbs or establishes a successful resistance. This latter contingency cannot be invoked in the present case, since *Sarcocystis muris* is fatal to mice.

The data above given were obtained only incidentally in the course of a study of the life history of *S. muris*, and hence cannot be regarded as at all conclusive.

MAURICE C. HALL, *Secretary*.

APPENDIX

For the convenience or information of investigators, attention is called to the place of publication of the earlier proceedings of the Helminthological Society of Washington. Previous to publication in THE JOURNAL OF PARASITOLOGY, all the Proceedings were published in *Science*, as follows:

Vol. 33, new series, No. 840, pp. 197-198, Feb. 3, 1911 (first and second meetings).

Vol. 33, new series, No. 848, pp. 510-512, March 31, 1911 (third meeting).

Vol. 33, new series, No. 850, pp. 590-592, April 14, 1911 (fourth meeting).

Vol. 33, new series, No. 860, pp. 974-976, June 23, 1911 (fifth and sixth meetings).

Vol. 35, new series, No. 901, pp. 553-556, April 5, 1912 (seventh, eighth and ninth meetings).

Vol. 35, new series, No. 903, pp. 635-636, April 19, 1912 (tenth meeting).

Vol. 35, new series, No. 906, p. 756, May 10, 1912 (eleventh meeting).

Vol. 37, new series, No. 941, p. 78, Jan. 10, 1913 (twelfth meeting).

Vol. 37, new series, No. 944, pp. 197-198, Jan. 31, 1913 (thirteenth meeting).

Vol. 37, new series, No. 952, pp. 498-499, March 28, 1913 fourteenth meeting).

Vol. 37, new series, No. 954, pp. 577-578, April 11, 1913 (fifteenth meeting).

BOOK REVIEWS

THE DIAGNOSIS AND TREATMENT OF TROPICAL DISEASES. E. R. Stitt. 421 pp. 86 illustrations. P. Blakiston's Son & Co., Philadelphia.

This work is more than ordinarily interesting to the parasitologist because of the position and work of the author, who has also written a good text on animal parasitology. The present book emphasizes the clinical aspect of the subject, and is intended as a companion volume to the earlier work. Fortunately, the idea is not carried out rigorously, for in each case a brief statement concerning laboratory diagnosis concludes the discussion of a particular disease.

The classification of diseases which is distinctly modern brings together those due to protozoa and those due to helminthes in two of the chief subdivisions of the text. The discussions of these organisms, while necessarily brief, are in the main very good, as they certainly are complete. The author's style is attractive and his knowledge of the literature in this field unusually broad. In a few cases poor figures were selected, but in general they are adequate, though variable in effect.

FLIES IN RELATION TO DISEASE: Bloodsucking Flies. Edward Hindle. Cambridge University Press. 1914. 8°. 398 pp. 88 figures.

This volume belongs to the Cambridge Public Health Series and is a companion volume to one on Non-Bloodsucking Flies. The introductory chapters discuss clearly and briefly the general problem of the indirect and direct transmission of pathogenic agents, the relation of the definitive and intermediate hosts and their parasites, the external and internal anatomy of adult flies, the anatomy and development of the immature stages and the classification of flies.

The general subject is introduced by a tabulation giving a complete list of the families containing bloodsucking species, a list of the species known to transmit an infective agent, the disease transmitted, their geographical distribution and the authorities responsible for the record. This table is supplemented by another giving the known species of Anophelinae, their present generic location, notes on their habits and connection with malaria. The text contains analytical tables for the identification of the families of Nematocera, Brachycera and Calyptratae, for the identification of the genera and species of Psychodidae and Culicidae, the genera of Muscidae and the species of Glossina.

The families are arranged in their systematic sequence, and under each there is given a detailed discussion with figures of the external and internal anatomy of the adults and immature stages, the habits and development of the immature stages, their enemies and means of combating them. Following the systematic discussion in each case, there is a careful consideration of what is known regarding the various diseases transmitted by bloodsucking flies and their causal organisms, the morphology, life cycle and development, and in many cases maps showing the geographical distribution of the insect carrying the parasite. The chapters dealing with malaria, yellow fever, dengue, filariasis and trypanosomiasis are especially full and to be commended. It is a well-arranged, clearly written, readable volume.

HANDBOOK OF MEDICAL ENTOMOLOGY. By William A. Riley, Ph.D., Professor of Insect Morphology and Parasitology, Cornell University; and O. A. Johannsen, Ph.D., Professor of Biology, Cornell University. Ithaca, N. Y.: The Comstock Publishing Co., 1915. 348 pp.

The appearance of this splendid volume will do much toward placing this country in a leading position in medical entomology, such as it now occupies in other branches of applied entomology. Moreover, the wide distribution which this work is certain to receive doubtless will cause an awakening of interest in

the subject and a recruiting of the workers from the ranks of the entomologists and medical men which should do much to further our altogether too meager knowledge of the relationship of insects and acarines to disease.

While the authors do not profess to have had extended experience in research along these lines, they show a broad acquaintance with the literature of the subject from ancient to modern times, and have exhibited marked skill in assembling in concise form the principal facts recorded by an army of investigators in all parts of the world.

The subject is treated by grouping the matter according to the way Arthropods are connected with the various maladies. It was expressly not the authors' desire to treat all of the diseases known to be carried by Arthropods, but to endeavor to cite a number of the best illustrations of the different methods by which insects act as disease vectors. This has resulted in the omission of some well-established cases in which insects play an important rôle. It is regrettable that more information might not have been given regarding the life history and habits of some of the Arthropods, as the possession of such knowledge lends much to the solution of the problems of insect control, and often suggests the potentialities of an insect or a group of insects in disease transmission.

The style of the authors is interesting, the print good and the illustrations, though largely borrowed, are well chosen and very satisfactorily reproduced. The compactness of the volume is also a desirable factor. Certainly the work will be of wide usefulness.

Some Minute Animal Parasites or Unseen Foes in the Animal World. H. B. Fantham and Annie Porter. 319 pp., 56 figures. Methuen & Co., Ltd., London.

The authors state that the aim of the book is to give a readable account, popular but accurate, of the life histories of some microscopic protozoal organisms that produce disease in higher animals, including man. Emphasis is laid on topics of economic importance: sleeping sickness, malaria, dysentery and kala-azar in man; tstse-fly disease and redwater in cattle; coccidiosis in game and domestic birds; certain fish maladies and insect diseases. The relations of parasites to their environment and to commerce are discussed in certain chapters, so that the needs of students, sportsmen, breeders are met, as well as those of general readers. The task is great and the book modest in size.

After reading it one lays the book aside with mingled feelings of satisfaction and regret; satisfaction that the authors have succeeded so well and regret that more topics are not handled in similar fashion by those who can speak with such authority on the subject treated. Especially in this country is there a dearth of books on the advances of science in definite directions that can be commended to the general reader unfamiliar with the intricate terminology and technicalities of the investigator. Usually either the men who know cannot write, or those who write do not know. But this volume is both accurate and attractive.

The senior author has done much fine work on difficult problems involving the Sporozoa, and the junior author has also demonstrated her grasp on parasitic protozoa, so that it is not surprising to find a masterful treatment of the topic. The work is marvelously complete when one considers the narrow limits of space and the complexity and unfamiliarity of the subject. Unlike most elementary treatises, this one is generous in the citation of authorities, and so far as noted accurate, a virtue conspicuous by its absence in most such books, One feels like applauding this virtue, because it is usually confined to more technical publications, and yet it is the general scientific reader who has most need to hear the names of those who have laid the foundations of the science.

Furthermore, this book reads well. Scientific terms are used sparingly, and when employed are carefully defined. The authors adopted the plan of discussing these organisms from the biologic rather than from the taxonomic standpoint, and while they use with accuracy the scientific names of the various

pathogenic protozoa and group them together in a fashion that accords with proper systematic conceptions, they avoid the introduction of a mass of classificatory subdivisions which impart such a ponderous impressiveness to many texts. The descriptions of the various life histories, which are of such significance in the transmission and prevention of disease, are both vivid and accurate. Even recently elucidated phenomena, such as granule-shedding in spirochetes and in the organism of syphilis, are explained clearly so that the work may be commended for its completeness as well.

The illustrations are rather scanty, perhaps because of the limited space, and some of them are distinctly wooden in being schematic to an unnecessary degree. Or if that feature was retained by choice, then they might have been reduced considerably to make space for other figures. Thus it was surely not necessary to use a full page for a diagram of the bee's alimentary canal; every detail represented would have been equally clear in a cut half the size or even smaller. For an audience of the type to which the book appeals, an abundance of illustrations is indispensable, as the descriptions alone give a vague idea of the appearance of such unfamiliar things. This is the one weak feature in a very successful work; yet despite it the book should be recommended widely and strongly to all seeking knowledge of this new and fascinating field of recent discoveries concerning life and disease.

NOTES

THE Preliminary Report of the Institute of Tropical Medicine and Hygiene of Porto Rico summarizes the work done during an expedition to the interior. In sixty working days over 10,000 persons were thoroughly examined. The report contains an interesting table of Diseases due to Animal Parasites.

DISEASES DUE TO ANIMAL PARASITES

	Primary	Secondary	Total
Uncinariasis (Necator americanus)	307	680	987
Ascariasis (Ascaris lumbricoides)	44	555	599
Trichuriasis (Trichuris trichiura)	1	152	153
Strongyloidosis (Strongyloides stercoralis)	.....	10	10
Balantidic Dysentery (Balantidium coli)	1	1	2
Oxyuriasis (Oxyuris vermicularis)	2	1	3
Amebiasis (Entameba histolytica)	3	1	4
Schistosomiasis (Schistosoma mansoni)	206	22	228
Malaria (Plasmodium vivax)	2	.....	2
Malaria (Laverania malariae)	6	.....	6
Filariasis (doubtful) (Filaria bancrofti)	4	1	5
Elephantiasis	.....	1	1
Distomiasis (Fasciola hepatica)	.....	1	1
Flagellate diarrhea, species undetermined	2	.....	2
	578	1,425	2,003
Total diseases treated	1,923	1,991	3,914

In the comment it is stated that in 1904 70 per cent. of cases at Utuado were found infected with hookworm and 90 to 98 per cent. at Mayaguez. The intensity of the infection and of the disease was much less this year. In ten years over 300,000 persons have been treated on government initiative and 200,000 on their own responsibility. Even yet 51 per cent. of all cases examined were found to be infected with hookworm.

Infection with roundworms was heavy beyond comprehension, but with comparatively few serious symptoms. Schistosomiasis was found mostly in persons living near the Vivi and Grand rivers and bathing in them. Only two foci of malaria were found, limited in area. The workers were entirely unable to find microfilaria in any case. The tropical form of ameba was not common at the time of the work.

The International Commission on Zoological Nomenclature has finally reached a decision with regard to the spelling of the scientific name of the European hookworm. This will be welcomed by all. The confusion of some twenty variants which have burdened our recent literature, and the appeals of partisans for their particular type have grown unendurable. Even those who do not like the form chosen must welcome a decision finally. Yet despite some murmurs from outside sources that this form, *Ancylostoma,* was not well chosen,[1] and granted that the German will always spell the name with a *k* and others will follow because it sounds right to them, one may confidently predict the early and general introduction of the new form. It is simple, philologically defensible, and if pronounced after the Latin method, just what every one has used here and abroad. Undoubtedly, the most important end is to secure uniformity and for that some system is demanded.

It is equally clear that the form of ankylostoma will persist as a common name alongside of the technical form, just as the common name trichina is in constant use, though the correct scientific designation is *Trichinella,* or as one speaks of crustacea and a host of other groups which are correctly written in the scientific form with a capital letter. The process of popularizing technical terms has already gone a long ways in medicine, botany, zoology and other fields of science, and with increasing knowledge and interest will go much further in the near future. We shall come to look to authoritative bodies in each field to determine spelling and usage for us, and will adopt the decision of such commissions without discussion when we have put into practice our theory that such bodies know better what should be done than the educated outsider can possibly determine by any investigation.

In the death of von Prowazek on February 17, last, parasitology has suffered an irreparable loss. Like his distinguished predecessor, Schaudinn, and our own Ricketts, he sacrificed his life at an early age in the pursuit of his investigations undertaken in the interest of science and humanity. When typhus broke out in a German prison camp he entered upon a study of the disease and fell a victim to it. As a brilliant thinker, a keen investigator and a voluminous writer he has already exercised a dominant influence on the development of this field of science. By virtue of work which has no limits in country or time and serves all nations for all ages, he was a benefactor of the whole world and will be honored as such.

1. Editorial, Jour. Am. Med. Assn., March 27, 1915, p. 1081.

INDEX TO VOLUME I

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No. 2. Dec. 18, 1914. No. 4. July 16, 1915.

The Journal of parasitology

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